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STUDIES ON POPULATION DYNAMICS AND SPACIAL DISTRIBUTION OF EPILACHNA BEETLE *HENOSEPILACHNA VIGINTIOCTOPUNCTATA* (FABR)

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(Received 1 December 1984)

Studies on population dynamics and spacial distribution of the epilachna beetle, *Henosepilachna vigintioctopunctata* infesting brinjal were conducted at Indian Institute of Horticultural Research, Hessaraghatta, Bangalore. Factors contributing to mortality of epilachna beetle determined during the course of its development through six generations are presented in life-tables. The larval-pupal parasite, *Pediobius foveolatus* (Crawford) was the major mortality factor. Distribution pattern of epilachna beetle under natural condition at different density levels of host plants revealed that larval population remained highly aggregative and was adequately explained by negative binomial distribution. The mean crowding (x^*) and Lloyd-index ($X^*/\bar{X}$) identified the egg laying pattern close to randomness but the data showed more fit to negative binomial distribution than Poisson distribution. The study revealed that aggregative behaviour of pest population was due to inherent property of insect and interplant density did not show any effect on the dispersion behaviour of epilachna beetle under natural conditions.

(Key words: population dynamics, epilachna beetle, *Henosepilachna vigintioctopunctata)*

INTRODUCTION

Among the insects that attack brinjal, potato and other solanaceous plants, the epilachna beetle, *Henosepilachna vigintioctopunctata* (Fabr.) is very important in India. It is one of the most widely distributed and presistent pests of solanaceous plants. Both the adult and larva feed and skeletonise the leaves and are observed as a very serious limiting factor in the cultivation of potato and brinjal (KRISHNAMURTY, 1932). *Henosepilachna* sp. was observed to feed on several plants including cucurbits and leguminous plants in different countries. Although the biology of pest has been studied in detail by many workers, it was felt that an attempt to understand the population dynamics of insect will provide the basis for formulating a sound pest-management approach.

The distribution behaviour of insects has direct bearing on reproduction and survival and is affected by physical factors in addition to reproductive behaviour and interaction with natural enemies. Most of insects rarely, if ever disperse themselves in purely random manner in their natural environments and in general, the departure from

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randomness is a direction toward aggregation or grouping. Aggregation behaviour of insect population has considerable ecological significance. The stability of distribution behaviour is an important characteristic to understand their population dynamics.

The present paper is concerned with the analysis of mortality of *H. vigintioctopunctata* infesting brinjal, using life-table approach and its distribution pattern at different level of density of host plants.

MATERIALS AND METHODS

Life-table and distribution studies were carried out at the Indian Institute of Horticultural Research, Hessarghatta, Bangalore. Six successive crops of brinjal (Var. *Pusa purple long)* were planted from February 1979 to July 1980. Observations were recorded on 200 randomly and tagged plants. Since all stages of pest from egg through pupal to adult are found distributed on the plant itself various observations related to different instars were directly recorded. Parasitism by *Pediobius foveolatus* (Crawford) was recorded in the field itself since parasitized grubs turned dark brown and mummified. The presence of other parasites were tested by collecting samples of all stages of pest from field and holding them in the laboratory until their emergence. All natural enemies associated with *H. vigintioctopunctata* were collected from the field, reared to adult stage and sent to Commonwealth Institute of Entomology, U. K., for identification. In construction of age specific life-tables, the technique of MORRIS & MILLER (1954) and of MORRIS (1963) were used. The numbers entering each interval were directly recorded in the field.

To study the distribution behavior, brinjal (Var. *Pusa purple long)* crop was transplanted in four blocks each separated by one meter distance during July 1980. The crop was spaced at a distance of 60 cm between the rows and 30, 40, 50 and 60 cm within the row. The blocks contained 192, 144, 120 and 96 plants for 30, 40, 50 and 60 cm distance respectively. The crop was raised without resorting to plant protection measures to allow the pest population to grow under natural conditions. The data was recorded on number of egg clusters and larval population on different dates from all the plant in different blocks throughout the life cycle of the pest. The data pertaining to different dates have been represented by set number for future discussion. In case of egg cluster counts, data on all the seven dates were pooled per plant to investigate the distribution pattern of egg clusters. For larval population, distribution behaviour has been studied for all the dates separately for all the interplant distances.

The data on egg cluster counts and larval population per plant were summarised in the form of frequency tables for statistical analysis and fitting of mathematical distribution. The nature of dispersion was assessed by dispersion parameter (K), mean crowding (X^*) and Lloyd index (X^*/X). Many workers (ANSCOMBE, 1949; WADLEY, 1950; EVANS, 1953; BLISS & OWEN, 1953; CHUA & LIM, 1977; SUMAN *et al.*, 1980, 1981) have described that insect populations showing aggregation dispersion can be adequately expressed by the negative binomial distribution. The disperson parameter of this distribution was calculated as

$$K = \frac{\overline{X}^2}{S^2 - \overline{X}}$$

Where $\overline{X}$ and S^2 are sample estimate of population mean and variance, this value of K was utilised to compute its maximum ikelihood estimate as explained by FISHER (1953) which was used to fit the negative binomial distribution.

RESULTS AND DISCUSSION

Life tables of six generations of *H. vigintioctopuntata* have been summarised in Table 1. The major mortality factor was operating during third instar to pupal stage. This was due to eulophid parasite *Pediobius foveolatus* (Crawford). Although, it attacked second instar grubs occassionally, its activity was concentrated mainly on late instar grubs and the extent of parasitism during the six generations ranged from 14.67 to

TABLE 1. Life tables of the epilachna beetle *Henosepilachna vigintioctopunctata* on brinjal.

Generation	X	lx	dx	dxF	qx	px	100x	k
	Age interval	Number alive at beginning of x	Number dying during age x	Factors responsible for dx	Proba-bility of death	Proba-bility of survival	dx as% of 1x	
	2	3	4	5	6	7	8	9
1. Egg		3445	2023	Mirid predator egg cannibalism by adult beetles.	0.5872	0.4128	58.72	0.3844
Larva 1		1422	1045	Predation by ants, fungal infection of grubs.	0.7348	0.2652	73.48	0.5765
Larva 2		377	205	Predation by ants, fungal infection *Beauveria tenella* (Del.) Siemask.	0.5438	0.4562	54.38	0.3408
Larva 3		172	84	Parasitism by *Pediobius foveolatus.*	0.4884	0.5116	48.84	0.2910
Larva 4		88	41	Parasitism by *P. foveolatus.*	0.4659	0.5341	46.59	0.2724
Pupa		47	6	Parasitism by *P. foveolatus.*	0.1277	0.8723	12.77	0.0593
Female x 2		41	—	—	—	—	—	—
Population Trend Index = 1.004, Generation survival = 0.0116								K = 1.9244
2. Egg		2459	539	Mirid predator, egg cannibalism by adult.	0.1558	0.8442	15.48	0.0736
Larva 1		2920	1717	Rain and predation by ants.	0.5880	0.4120	58.80	0.3850
Larva 2		1203	646	Rain, predation by ants and pentatomid bugs.	0.5370	0.4630	53.70	0.3344
Larva 3		557	152	Parasitism by *P. foveolatus* & predation by pentatomid bug.	0.2729	0.7271	27.29	0.1384
Larva 4		405	293	Parasitism by *P foveolatus.*	0.7234	0.2765	72.34	0.5583
Pupa		112	33	Parasitism by *P. foveolatus.*	0.2946	0.7054	29.46	0.1516
Female x 2		79	—	—	—	—	—	—
Population Trend Index = 2.786, Generation Survival = 0.023								K = 1.6413
3. Egg		9639	2104	Infertility of eggs and cannibalism by adult	0.7817	0.2183	21.83	0.1069
Larva 1		7535	1995	Rain, and predation by ants.	0.7352	0.2648	26.48	0.1336

Contd.

Table 1 Contd.

1	2	3	4	5	6	7	8	9
	Larva 2	5540	1439	Predation by ants and parasitism by *P. foveolatus*.	0.7403	0.2597	25.97	0.1306
	Larva 3	4101	929	Parasitism by *P. foveolatus* and unknown causes.	0.7735	0.2265	22.65	0.1116
	Larva 4	3172	1130	Parasitism by *P. foveolatus*.	0.6438	0.3562	25 62	0.1912
	Pupa	2042	1021	Parasitism by *P. foveolatus*.	0.5000	0.5000	50.00	0.3011
	Female x 2	1021	—	—	—	—	—	—
Population Trend Index = 0.636, Generation Survival = 0.105								K = 0.9750
4.	Egg	6132	2007	Mirid predator, inferitility and egg cannibalism.	0.3273	0.6727	32.73	0.1722
	Larva 1	4125	1397	Rain and predation by ants.	0.3343	0.6657	33.43	0.1767
	Larva 2	2746	683	Rain, predation by ants and pentatomid bugs.	0.2487	0.7513	24.87	0.1242
	Larva 3	2063	360	Predation by pentatomid bugs and parasitism by *P. foveolatus*.	0.1745	0.7217	17.45	0.0833
	Larva 4	1703	915	Parasitism by *P. foveolatus*.	0.5373	0.2765	53.73	0.3347
	Pupa	788	461	Parasitism by *P. foveolatus*.	0.5926	0.7054	59.26	0.3900
	Female x 2	321	—	—	—	—	—	—
Population Trend Index = 1.143, Generation survival = 0.052								K = 1.2811
5.	Egg	7011	1662	Parasitism by *Tetrastichus ovulorum*, infertility, cannibalism.	0.2371	0.7629	23.71	0.1175
	Larva 1	5349	697	Predation by ants and unknown causes.	0.1303	0.8697	13.03	0.0607
	Larva 2	4652	639	Predation by ants and parasitism by *P. foveolatus*.	0.1347	0.8626	13.74	0.0641
	Larva 3	4013	589	Parasitism by *P. foveolatus* and unknown.	0.1467	0.8532	14.67	0.0690
	Larva 4	3424	1081	Parasitism by *P. foveolatus* and unknown.	0.3157	0.6843	31.57	0.1629
	Pupa	2343	664	Parasitism by *P. faveolatus* and unknown.	0.2834	0.7166	28.34	0.1465
	Female x 2	1679	—	—	—	—	—	—
Population Trend Index = 0.446, Generation survival = 0.239								K = 0.6707

Contd.

Table 1 Contd.

1	2	3	4	5	6	7	8	9
6.	Egg	3129	1185	Infertility, cannibalism and unknown.	0.3787	0.6213	37.87	0.2067
	Larva 1	1944	872	Rain and predation by ants.	0.4485	0.5514	44.85	0.2585
	Larva 2	1072	582	Predation by ants, parasitism by *P. foveolatus* and unknown.	0.5429	0.4571	54.29	0.3400
	Larva 3	490	300	Parasitism by *P. foveolatus* and unknown.	0.6122	0.3878	81.22	0.4114
	Larva 4	190	70	Parasitism by *P. foveolatus* and unknown.	0.3684	0.6316	36.84	0.1996
	Pupa	120	80	Parasitism by *P. foveolatus* and unknown.	0.6667	0.3333	66.67	0.4771
	Female x 2	40	—	—	-		—	

Population Trend Index = Generation survival = 0.0128 K = 1.8933

72.34 per cent. PUTTARUDRIAH & KRISHMAMURTHI (1954) stated that the larvae of *E. vigintioctopunctata* were attacked by *P. foveolatus* and percentage of parasitism reached 70–74 in February and March and 68 in July and according to them insecticidal control was found inadvisable whennatural incidence of parasitism was high.

It is seen from life-tables that predatory ants *Solenopsis geminata* (Say) played an effective role in reducing the pest population. The early larval instars were removed from plants by these ants. They were active when there was sufficient moisture around the roots, usually soon after irrigation. These ants were also found feeding on growing shoot tip.

The mortality suffered at egg stage ranged from 15 to 58 per cent during six generations. The main factor responsible for this was cannibalism of eggs by adults of epilachna beetle, the egg cluster within the top portion eaten away was a typical symptom of cannibalism. Predation by mirid bugs *Deraecoris* sp.? *indianus* (Carvalho) was evident from collapsed appearance os chorion. Feeding by predator was by puncturing the chorion and sucking out the content of egg. This is the first record of *Deraecoris* sp. as a predator on eggs of *H. vigintiactopunctata*. The failure of several infertile eggs to hatch contributed from 8 to 14 per cent to mortality throughout the period of study. The egg parasite *Tetrastichus ovalorum* (Ferriere) was reared from epilachna eggs during April 1980. The parasitism in the field during this period was estimated to be 6.8 per cent on an average.

During the second and fourth generations predation by pentatomid bugs, *Cantheconidea furcellata* (Wolff) and *Andrallus spinidens* (Fabr.) were

recorded in addition to other factors. Nymph and adult of both bugs were found feeding extensively on grubs, pupa and adult of *H. vigintioctopunctata*. Because of this the extent of predation during these generations was more as compared to others. In other generations these pentatomid predators were not present as conditions favouring their activity may not have been congenial.

Rain too played its role in reducing the population of early instar grubs. It is seen from six life-tables that although there was wide range in mortality suffered by all stages of epilachna beetle, no single factor was consistently responsible for fluctuations in the population size within each generation. Trend indices worked out also indicated that there is a considerable amount of fluctuation between these generations, some recording an increase over the previous and other showing decreasing trend. These flucatuations are because of different degree of natural control experienced during different generations. The generation survival for each generation was estimated. It clearly indicated that there is a great deal of reduction in the population size within each generation which in turn reflects an effective role of natural process operating to check biotic potential of this pest insect. The variations in generation survival are because of the extent of mortality from egg to adult stage in each generation differed.

Statistical parameters for dispersion behaviour of egg cluster counts and larval population of epilachna beetle are shown in Tables 2 and 3 respectively. Highest number of egg clusters per plant (1. 9747) was observed in interplant distance 30 cm followed by 60 cm (1.7812) and 40 cm (1.0903) indicating that interplant distance of host does

TABLE 2. Statistical parameters for dispersion behaviour of egg cluster of epilachna beetle

Distance	Mean	Variance	K	Mean crowding	Lloyd index	CHI-square	D.F.	Distribution type
30 cm	1.9747	0.9087	—	1.4346	0.7265	1.9742	3	N
						2.4888	3	P
						1.8517	3	B
40 cm	1.0903	1.2575	7.1079	1.2436	1.1407	1.1542	4	N
						1.4542	4	P
						5.3422	3	B
50 cm	1.0333	1.1754	7.5787	1.1708	1.1331	0.8227	3	N
						2.1184	3	B
						11.6293	3	P
60 cm	1.7812	1.5411	—	1.6465	0.9243	—	—	—
						8.7850	4	P
						5.4348	3	B

N Mean negative binomial distribution.
P Mean Poisson distribution.
B Mean binomial distribution.

TABLE 3. Statistical parameters for dispersion behaviour of larval population of *Henosepilachana* beetle.

Set	Plant distance	Mean density (x)	Variance (S^2)	Dispersion parameter K	M L E of K	Mean crowding	Value Lloyd index	CHI-square value	D.F.	Probability of fit between
I.	30	1.4323	19.3619	0.1212	0.1103	13.2522	9.2524	6.4352	6	0.30—0.50
	40	4.1181	104.8601	0 1684	1.2612	28.5813	6.9904	6.3852	7	0.30—0.50
	50	5.1583	83.9495	0.3138	0.2991	20.3429	3.9612	9.8203	9	0.30—0.50
	60	5.3958	85.5469	0.3633	0.3615	20.2501	3.7529	7.0732	9	0.50—0.70
II.	30	2.6406	53.9696	0.1358	0.1309	22.0790	8.3614	5.7908	8	0.50—0.70
	40	6.8056	158.0738	0.3062	0.2320	29 0326	4.2660	8.2234	10	0.30—0.50
	50	5.8917	104.0974	0.3462	0.3446	26.8005	3.8888	23.6557	11	0.01—0 02
	60	9.4688	182.4201	0.5184	0.4115	27.7342	2 9229	4.7594	10	0.90—0.95
III.	30	2.6458	74.1357	0.0979	0.1237	29.0659	11 2125	10.1515	8	0.20—0.30
	40	4.5556	64.8221	0.3444	0.3150	17.7847	3 9039	8.5861	10	0.50—0.70
	50	7.9500	170.7706	0.3882	0.3064	28.4306	3.5761	22 3348	11	0.01—0.02
	60	10.3021	203.8552	0.5489	0.5097	29.0888	2.8236	10.3024	11	0.30—0.50
IV.	30	3.2760	60.5360	0.1879	0.1452	20.7546	6 3354	8.8171	9	0.30—0.50
	40	3.5486	42.0815	0.3268	0.3180	14.4072	4.0599	5.8206	9	0 70—0.80
	50	5.7833	70.3056	0.5184	0.4467	16.9399	2 9291	18.1376	11	0.05—0.10
	60	8.3646	93.3709	0.8231	0.5814	18.5272	2 2150	19.4288	13	0.30—0.50
V	30	1.4167	16.6737	0.1314	0.1161	12.1880	8.6017	4.3815	6	0.30—0.50
	40	1.5750	10.6416	0.4010	0.3422	6.5506	3 4936	5.0733	7	0.50—0.70
	50	4.1500	34.1622	0.5739	0.5754	11.3811	2.7926	9.8104	9	0 30—0.50
	60	5 6667	49.6140	0.7307	0.6515	13.4221	2.3688	6.6427	10	0.70—0.80
VI.	30	0 7656	7.4788	0.0873	0.0791	9.5341	12.4532	2 4796	4	0.50—0.70
	40	0.3403	0.6037	0.4396	0.9313	1.1143	3 2745	0.0609	2	0.95—0.70
	50	0.8333	2.4090	0.4407	0.4169	2 7242	3.2692	4.1657	4	0.30—0.50
	60	2.4479	8.9657	0 9199	0.8287	5.1105	3.0877	1.6871	6	0.90—0.95
VII.	30	0.4583	2.5009	0.1008	0.0903	4.9152	10.7249	2.5131	4	0.50—0.70
	40	0.1458	0.1674	0.9863	0.8466	0.2939	2.0161	0.0111	1	0.95—0.98
	50	0.1500	0.1789	0.7761	1.1093	0.3427	2 2843	0 0046	1	0.95—0.98
	60	0.6855	1.7539	0.4432	0.4894	2.2386	3 2562	0.4368	3	0.90—0.95

not have any effect on egg laying pattern and eggs are laid randomly. The varaince was either less than mean or varied nonsignificantly from mean and indicated the tendency toward randomness in all the interplant distances was maintained. The fact that mean density of larval population increased with increase of interplant distance in all the sets indicated better growth development of pest population when the crop was spaced at more interplant distance. Highest larval population for interplant distance of 30 cm and 40 cm was observed in sets 4 and 2 respectively whereas set 3 contributed high population for interplant distance of 50 and 60 cm. Such variations might be due to adult population which continued to lay eggs for two weeks during the period of study.

The value of variance for larval population was significantly higher than mean for all the interplant distances in all the sets and this indicated aggregation behaviour of larval population. It further revealed that aggregation behaviour of larval population is not affected by interplant distances and population remains highly aggregative. The value of variance in all the interplant distances increased till set 3 and thereafter, it decreased indicating more homogeneity of data during latter stage of the pest life cycle.

The value of disperson parameter for egg cluster counts was either negative or high which further revealed the random behaviour irrespective of interplant distances. In case of larval population the value of dispersion parameter increased with increase of interplant distance except in set 7 where it decreased for 50 and 60 cm interplant distances. Generally, the value of dispersion parameter decreased when its maximum liklihood estimates was calculated. This indicated strong association of larval population to aggregation irrespective of interplant distance of host.

Mean crowding (X*) value for egg cluster counts did not differ significantly from unity indicating closeness toward randomness. In case of larval population this index yielded significantly higher value than unity in all the sets and interplant distances. These results revealed that the larval population has strong tendency toward aggregation irrespective of interplant distances of host. LLOYD (1967) index of patchiness, which is the ratio of mean crowding and mean, is an appropriate index of dispersion. This index also supported the random dispersion of egg cluster counts at lower level of population density and approach toward aggregation at higher level of population density. In case of larval population this index showed significantly higher value than unity in all the interplant distances indicating that larval population follows contagious distribution. The stability of Lloyd index indicated that larval population remained aggregative at all levels of interplant density.

Though the random dispersion has been observed for egg cluster counts, data showed more closeness toward negative binomial distribution (Table 2). This revealed that egg laying pattern followed random dispersion but has strong tendency toward aggregation. In the case of larval population data showed good agreement between observed and expected frequencies of negative binomial distribution for all the sets

irrespective of interplant distance (Table 3).

The study on distribution of epilachna beetle indicated that the larval population is highly aggregative and can be adequately explained by negative binomial distribution. Interplant density does not have any effect on distribution behaviour of epilachna beetle.

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EVALUATION OF INSECTICIDES AGAINST EPILACHNA BEETLE INFESTING BITTERGOURD AND THEIR IMPACT ON *PEDIOBIUS FOVEOLATUS* (CRAWFORD)

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Field efficacy of synthetic pyrethroids along with some conventional insecticides was studied against epilachna beetle, *Henosepilachna vigintioctopunctata* (Fabricius) infesting bittergourd. The impact of insecticides on larval pupal parasite, *Pediobius foveolatus* (Crawford) was also studied. All the sythetic pyrethroids viz., fenvalerate, cypermethrin, deltamethrin and permethrin were highly effective against the beetle, but resulted in very high kill of developing parasite inside the treated host.

(Key words: Henosepilachna vigintioctopunctata, Pediobius foveolatus, synthetic pyrethroids, bittergourd)

INTRODUCTION

The epilachna beetle, *Henosepilachna vigintioctopunctata* (Fabricius) is a serious pest of many vegetable crops belonging to Solanaceae and Cucurbitaceae (LALL, 1964). *Pediobius foveolatus* (Crawford) has been reported to be parasitic on the grubs of epilachna beetle in Mysore (KRISHNAMURTI, 1932), Bihar (LALL, 1946) and Uttar Pradesh (LAL & GUPTA, 1947). Natural parasitization ranging from 60 to 77 per cent has been reported from Karnataka (APPANNA, 1948; PUTTARUDRAIAH & KRISHNAMURTI, 1954; PATALAPPA & CHANNA BASAVANNA, 1979). Earlier different insecticides have been tested against epilachna beetle infesting brinjal (LEELA DAVID, 1963; BUTANI & VERMA, 1976; NAIR & NAIR, 1976; TEWARI & KRISHNA MOORTY, 1983), but no report is available on the control of epilachna beetle as bittergourd pest. Hence a study was conducted to find out the effectiveness of some newer insecticides against epilachna beetle infesting bittergourd. Their effect was also tested on *Pediobius foveolatus* (Crawford) (Hymenoptera : Eulophidae), an effective natural enemy of the epilachna beetle.

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MATERIALS AND METHODS

Two field experiments were conducted in a randomized block design with bittergourd variety '*Arka Harit*' one each in summer and rainy season, 1984. There were ten insecticidal treatments (Table 1), each replicated thrice along with a control. Individual plot size was 10 m row. Data on pre- and post-treatment counts of total grubs and adults per plot were collected and statistically analysed to find out the effectiveness of the treatments against epilachna beetle. During summer season experiment when the parasitization was high, 15 randomly selected parasitized grubs and pupae, distinguished on the basis of symptoms described by PATALAPPA & CHANNA BASAVANNA (1979), were collected from each

treatment before and after the application of insecticides. They were kept in the laboratory at 29 ± 1°C in glass tubes (15 cm × 1.5 cm) for adult emergence. Data on total number of adults emerged in each tube were recorded and statistically analysed.

RESULTS AND DISCUSSION

All the treatments were significantly superior to the control in reducing the beetle population at least upto 10 days after application in both the seasons. Synthetic pyrethroids fenvalerate, cypermethrin and deltamethrin were found to be the best resulting in a minimum beetle population. Permethrin, fenthion, endosulfan and monocrotophos were moderately effective. Phosalone and phosphamidon were significantly less effective against epilachna beetle. The results were consistent in both the seasons.

The synthetic pyrethroids cypermethrin, fenvalerate, permethrin and deltamethrin were highly toxic to the parasite inside host grubs. The number of parasites emerged per treated host grub ranged from 0.33 to 0.93 whereas control resulted 11.87 parasites per host grub. Phosphamidon, carbaryl and fenthion were moderately toxic to the parasite whereas endosulfan and phosalone were found to be comparatively safer resulting in 8.13 and 7.33 parasites respectively per treated host grub.

Thus endosulfan and phosalone though moderately effective against the epilachna beetle, were found to be less toxic to parasite, *Pediobius foveolatus* (Crawford). All the synthetic pyrethroids were highly effective against the epilachna beetle but were also very toxic to its natural enemy. Earlier, synthethetic pyrethroids have been found to be effective against epilachna beetle infesting brinjal (TEWARI & KRISHNA MOORTI, 1983). Endosulfan (BUTANI & VERMA, 1976), endosulfan in combination with dipel (BASKARAN & KUMAR, 1980) and carbaryl (LEELA DAVID, 1964; NAIR & NAIR, 1976) were also reported to be effective in controlling the epilachna beetle feeding on brinjal. The present results are in conformity with those of TEWARI & KRISHNA MOORTHY (1983) who demonstrated the detrimental effect of synthetic pyrethroids aganist *Pediobius foveolatus* (Crawford) and reported that endosulfan was the safest insecticide resulting in maximum safety index to the parasite.

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TABLE 1. Efficacy of insecticides against epilachna beetle and its parasite, *Pediobius foveolatus* (Crawford)

Treatment	Dose ai/ha (g)	*H. vigintioctopunctata*							*P. foveolatus* No. parasite parasitized grub	
		Summer season			Rainy season					
		Pre-treatment count	Post-treatment count after			Pre treatment count	Post-treatment count after			
			24 h	5 days	10 days		24 hr	5 days	10 days	Pre-treatment count	Post treatment count
Fenvalerate	75	59 67 (1.78)	0.33 (0.10)^{a}	0.67 (0.20)^{a}	3 00 (0.54)^{a}	41 33 (1.62)	0.33 (0 10)^{a}	0 67 (0.16)^{a}	1 00 (0 26)^{a}	10 53 (1.05)	0 93 (0.17)^{a}
Cypermethrin	50	62.33 (1 79)	0.33 (0 10)^{a}	1 33 (0.30)^{a}	4.00 (0.69)^{a}	36.33 (1 57)	0 67 (0.16)^{a}	0 33 (0 10)^{a}	2 00 (0.46)^{a}	11.60 (1.09)	0.60 (0.13)^{a}
Deltamethrin	10	56.00 (1.75)	0.67 (0.16)^{a}	1 33 (0.36)^{a}	2.33 (0.41)^{a}	42.67 (1.64)	0 33 (0 10)^{a}	1 33 (0.36)^{a}	1 33 (0.30)^{a}	12 67 (1 12)	0.67 (0 14)^{a}
Permethrin	100	60 33 (1.79)	1.67 (0.41)^{a}	4 00 (0 69)^{a}	9.67 (0.99)^{b}	39 00 (1 60)	1 33 (0 36)^{ab}	3.33 (0.63)	5 33 (0.78)^{b}	12.27 (1 11)	0.33 (0.09)^{a}
Carbaryl	1000	63.00 (1 80)	6.67 (0.85)^{de}	10 67 (1.06)^{cd}	16 00 (1.22)^{de}	39 67 (1 61)	8 67 (0.96)^{de}	9 33 (1.01)^{de}	12 33 (1.11)^{de}	11.73 (1.09)	3 67 (0.53)^{b}
Endosulfan	700	62.00 (1 79)	3 33 (0.62)^{bcd}	7 67 (0.93)^{bcd}	14.00 (1.15)^{de}	37.67 (1.59)	5 00 (0.75)^{cd}	5 00 (0.76)^{bcd}	11.00 (1.07)^{c}	11 80 (1.10)	8.13 (0.94)^{cd}
Monocrotophos	700	55 33 (1.75)	4 67 (0.75)^{cd}	5.33 (0.78)^{b}	15.33 (1 20)^{de}	41 33 (1.62)	3 00 (0 59)^{c}	1 33 (0 32)^{a}	4 67 (0.74)	12 60 (1 12)	6.27 (0.77)^{c}
Phosalone	700	62 33 (1.80)	10.00 (1.03)^{e}	8.00 (0.94)^{cd}	22 67 (1.37)^{e}	40.33 (1 61)	3 33 (0.62)^{b}	7.33 (0.92)$^{b-e}$	14.67 (1 18)^{de}	11.53 (1.08)	7.33 (0.89)^{cd}
Phosphamidon	500	58.67 (1 77)	10.00 (1.02)^{e}	14 00 (1.16)^{d}	21.67 (1.33)^{e}	39.33 (1 60)	9 33 (1.01)^{e}	12.33 (1 12)^{e}	22.67 (1.3.)^{e}	11 87 (1.09)	3.07 (0 49)^{b}
Fenthion	700	65.33 (1 82)	3.00 (0 54)^{bc}	5 67 (0 81)$^{b-e}$	11.67 (1.09)^{de}	37 67 (1 59)	2.33 (0 52)^{b}	4 33 (0.72)^{b}	9.67 (1 02)^{cd}	11.93 (1.10)	3 80 (0.55)^{b}
Control	—	62,67 (1.80)	61 00 (1.79)^{f}	63 00 (1.80)^{e}	65 67 (1.82)^{a}	37 00 (1 58)	40.00 (1 61)^{f}	47.67 (1 68)^{f}	56 33 (1.76)^{f}	11.87 (1.10)	11 87 (1 09)^{d}
CD at 5%		(NS)	(0.25)	(0.26)	(0.32)	(NS)	(0.25)	(0.26)	(0.26)	(NS)	(0.20)

Figures in parantheses are transformed values (Log x + 1)
Treatment means followed by the same alphabet are not significantly different.

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EFFECT OF THIOTEPA ON LARVAL GROWTH, EGG LAYING AND HATCHABILITY IN *PHILOSAMIA RICINI* (L).

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Administration of sublethal doses of thiotepa to castor silk moth, *Philosamia ricini* (L) larvae resulted in decrease in larval growth, total number of eggs laid, percentage of cocoon formation, and also in silk production. The increase in dosage of thiotepa also causes reduction in the hatchability of eggs.

(Key words: thiotepa, larval growth, egg laying, hatchability, *Philosamia ricini)*

INTRODUCTION

Wide variety of chemosterilants have been used successfully for causing partial to complete inhibition of oviposition and reduction in egg number and egg hatchability in a number of different insect species (CAMPION, 1972; MORGAN & LABRECQUE, 1962, 1964; RAI, 1964; LANDA & REZABOVA, 1965; LACHANCE *et al.*, 1968; TANEJA *et al.*, 1979). There is however dearth of investigation on the effects of these chemosterilants on the larval Lepidoptera and their subsequent development, reproduction, oviposition and hatchability of eggs; in most of the Lepidoptera completion of oocyte growth takes place during the pupal period. The present studies show the effect of different doses of thiotepa, an active alkylating agent, on the final instar larva and its subsequent development, cocoon formation, oviposition and rate of hatchability of eggs of the adults emerged from treated larvae of castor silk moth, *Philosamia ricini*.

MATERIALS AND METHODS

The eggs of castor silk moth were obtained from Khurdha eri seed station. Complete rearing of the insect was done in the laboratory at temperature of 28°C to 30°C. The larvae were fed on castor leaves. The insect passes through five larval instars before change into pupa. The chemosterilant was injected in the fifth instar larvae immediately after moulting from the fourth instar. The larvae were divided into four main groups of 50 each. One of the groups 'C' forms the control and other three groups i. e., 'X', 'Y' and 'Z' were injected with 5μg, 10μg and 15μ g thiotepa respectively. These larvae were also fed on castor leaves for completion of their life cycle.

RESULTS

Larval weight and cocoon formation:

There has been a decrease in the weight of larva in the treated groups. This has been found to be inversely propotional to the increase in the dosage of the chemosterilant as shown in Table 1. The administration of chemosterilant has also affected the formation of the cocoon. The number of cocoons formed decreased with the increase of dosage as shown in Table 1. The chemical has thus increased the rate of mortality of the larvae as they failed to spin the cocoon. The dry

TABLE 1. Effect of thiotepa on larval growth, and cocoon formation.

Insect feed	Group 'C' (control)	Group 'X' (5 μg)	Group 'Y' (10 μg)	Group 'Z' (15 μg)
Weight of larvae before spinning (gm)	3.45 ± 0.10	3.18 ± 0.15	3.01 ± 0.09	2.73 ± 0.10
Dry cocoon weight (mg)	348.0 ± 5.0	337.0 ± 5.0	321.0 ± 6.0	289.0 ± 4.0
% of cocoon formation	96	89	81	73

weight of cocoon has also been inversely affected by the increase in the dosages as shown in Table 1.

Oviposition and hatchability:

After completion of pupation period, the adults of both sexes were collected separately from each group. They were allowed to mate and lay eggs. Observations were made on the oviposition and hatchability rate of these eggs.

After completion of mating, the females started laying eggs which continued for three days. The average number of eggs laid in the control group 'C' was found to be 469. Gradual decrease in the average eggs laid was observed in the groups 'X', 'Y' and 'Z' respectively as shown in Table 2.

In the control group hatching started 8 days after laying of eggs. Hatching continued for 6 days.

TABLE 2. Effect of thiotepa on egg laying and rate of hatchability.

Groups	Total average eggs laid per insect	Total % of hatching
C	469 ± 10	76.70
X	426 ± 10	63.99
Y	398 ± 8	47.99
Z	310 ± 10	39.0

The rate of hatchability in group 'C' was maximum on the first day (22.7%) which decreased gradually upto the 6th day when it was found only to be 2 55 per cent. In the adults emerged from 'X' group larvae, hatching, like the control group, also took place 8 days after laying the eggs; however, hatchabibity was less on the first day (4.92%) and maximum on the second day (23.87%). This gradually decreased on the 3rd (17.32%) and 4th day (12.67%). Like the control group there was appreciable decrease in the hatchability on the 5th and 6th day after which no eggs were laid. In the 'Y' group, there was delay of 24 hours in the hatchability and the hatchability on the second day (12.94%) was less than those of 3rd (15.20%) and 4th day (13.13%). Appreciable decrease in the hatchability was also found on 5th and 6th day. In the 'Z' group like 'Y' group, there was no hatchability on the first day while it was maximum on the third day (13.90%) and appreciable decrease was observed on 5th (2.80%) and 6th day (3.64%). It has been thus observed that there was gradual decrease in the hatchability in treated groups which is inversely proportional to the dosages as shown in Table 3.

DISCUSSION

The decrease in the weight of larvae and the weight of cocoon in the treated

TABLE 3. Rate of hatchability on different days.

Groups	Percentage of hatchability on different days					
	First day	Second day	Third day	Fourth day	Fifth day	Sixth day
C	22.7	16.88	15.79	15.63	3.15	2.55
X	4.92	23.87	17.32	12.67	3.28	1.92
Y	—	12.94	15.20	13.13	3.58	3.14
Z	—	7.37	13.90	11.29	2.80	3.64

group as compared with the control group ascertains that the chemosterialant is in some way affecting the metabolism of the insect. Since the silk is mainly formed of proteins the reduction in the weight of cocoons or the silk yield indicates decrease in the protein synthesis. The factor has also been interfering with formation of oocytes and thus causing reduction in the number of eggs laid by the females emerged from the treated larvae (RAI, 1964; SUKUMAR & NAIDU, 1973; TAN, 1974; TANEJA *et al.*, 1979). The chemosterilant has also been found to have an adverse effect on hatchability of eggs. The total percentage of eggs hatched has decreased with the increase of the dosage. The higher dosages of 10 and 15μg of thiotepa also has delayed the hatching of the eggs by 24 hours.

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EFFICACY OF OILS FROM MEDICINAL PLANTS AS PROTECTANTS OF GREEN GRAM AGAINST THE PULSE BEETLE *CALLOSOBRUCHUS CHINENSIS*

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Oils extracted from five medicinal plants were assayed for their ovicidal, repellent and protectant properties against *Callosobruchus chinensis* L. infesting green gram *Vigna radiata* (Wilcz). Per cent oviposition on seeds was significantly reduced when oils from rhizomes of *Acorus calamus* and *Curcuma amada*, and seeds of *Carum copticum* and *Bassia longifolia* were applied at doses of 0.25 and 0.50 ml/kg seed. Reduction in oviposition on treated grains was mainly because of high insect mortality and repellency. Egg hatching was also significantly lower at the tested concentrations. Oils of *A. calamus* at 1 ml kg seed offered high degree of protection upto a period of 135 days, while oils of *C. amada* and *C. copticum* at the above mentioned concentration protected the seeds for 90 days only. Prolonged protection of green gram seeds was mainly due to reduced oviposition, low hatching and high adult mortality. Germination of the treated seeds with effective doses was not impaired to any significant extent.

(Key words: Callosobruchus chinensis, green gram, oils, oviposition, egg hatch, ovicidal, adult emergence, protection)

INTRODUCTION

Green gram, *Vigna radiata* (Wilcz) is one of the important pulse crops grown in India. Severe losses of the pulses is reported due to attack of bruchids (MOOKHERJEE *et al.*, 1970). As pulses are a major source of plant proteins and minerals etc. of high biological value, there is need to protect them from insect attack during storage. Many synthetic insecticides have been found effective for control of bruchids at farm levels but the hazards due to residual insecticides are well known; hence safer alternatives are essential. Mixing of oils with the pulses to protect from insect attack has been an ancient Indian practice. More recently, many reports are available regarding use of vegetable oils for protection of stored pulses (MUMMIGATTI & RAGHUNATHAN, 1977; SINGH *et al.*, 1978; VARMA & PANDEY, 1978: SCHOONHOVEN, 1978; PEREIRA, 1983; MESSINA & RENWICK, 1983). However, information on the use of oils from other botanical sources is scanty. Hence, in the present studies, oil from five indigenous medicinal plants have been evaluated for their efficacy for prolonged periods as surface protectants of green gram against *Callosobruchus chinensis* L. infestation.

MATERIALS AND METHODS

The plant materials *viz.*, rhizomes of *Acorus calamus* and *Curcuma amada* and seeds of *Carum copticum, Nigella sativa* and *Bassia*

longifolia were procured locally. The plant materials were dried in a hot air drier at 40°C and powdered to 60 mesh in a Raymond's Hammer mill. The powders were extracted thoroughly in cold petroleum ether (40–60°C B P) and excess of solvent was evaporated in a rotary flash evaporator at low temperature.

Green gram, *Vigna radiata*, was cleaned and disinfested by keeping at—18°C for two weeks. The disinfested samples were brought to equilibrium moisture of 12% by conditioning at 70% RH prior to use for experimental purpose.

Callosobruchus chinensis adults were obtained from laboratory cultures maintained on green gram at 27±2°C temperature and 65—75% RH. The experiments were also conducted at the above mentioned temperature and relative humidity.

To evaluate the ovicidal activity of oils, 100 g sample of disinfested green gram was treated with required quantities of each oil to give doses of 0.25 and 0 50 ml kg seed. The coated sample of each treatment was divided into five replicates of 20 g each and was kept in 170 ml bottles. Each control also had five replicates and there were separate controls for each oil. Five pairs of *C. chinensis* adults (0—24 hr old) were placed in each replicate and covered with muslin cloth. Observations on the adult mortality were recorded periodically for seven days, after which the adults were discarded. After 14 days, total number of eggs (hatched or unhatched) were counted in the 20g sample. Egg that turned white and opaque were judged as hatched and emerging adults were scored every other day. For each treatment, the number of eggs counted is represented as percentage of control.

Another experiment was conducted to determine the repellent action of four oils against *C. chinensis* adults, when a choice was given between control and treatments. Two concentrations of 0.25 and 0.50 ml/kg were tested for each treatment. Each experiment consisted of two sets and each set had three small petridishes for control and both the concentrations containing 5 g sample of treated and untreated seeds respectively. All the nine petridishes were placed in a big dish and covered with a dish of same size. One-day old adults of *C. chinensis* numbering 100g were introduced in the centre of the big dish. All insects dead or alive, were discarded after 24 h exposure.

To determine the efficacy of oils for prolonged period against the bruchid, the procedure was modified and higher dosages were chosen. Oils calculated to give doses of 1, 2 and 5 ml kg seed were pipetted out on to 200 g sample and mixed in a rotary shaker for 15 minutes. Each dosage had three replicates containing 50 g sample and there were separate controls for each treatment. Initially, ten pairs of 0—24 h old adults were introduced in each replicate including controls. After 45 days, data on grain damage was recorded and a second batch of ten pairs of insects were released in the treatments. A third batch of insects were released in all the concentrations of *A. calamus*, *C. amada* and *C. copticum* and 5 ml kg concentration of *B. longifolia* after 90 days. However, fresh batches of insects were not introduced in controls and some concentrations of *B. longifolia* and *N. sativa* oils as there was natural increase in the insect population. Observations on per cent grain damage in controls and treatments were recorded periodically after 45, 90 and 135 days. A germination test was also conducted according to International seed testing methods (ANONYMOUS, 1959). Statistical analysis was carried out by using analysis of variance whereever necessary.

A separate experiment was also carried out to evaluate contact action of the three promising oils i. e., *A. calamus*, *C. amada* and *C. copticum* against the adults of *C. chinensis*. Different concentrations of oils were prepared in acetone and coated on to the petridish (64 cm^2). In each replicate, 25 adults were introduced and there were four replicates. Mortality counts were recorded after 24 hr exposure. Per cent mortality was corrected using ABBOTT's (1925) formula and LD_{50} values calculated employing probit analysis (FINNEY, 1952).

RESULTS

Effect of various oils on adult survivavl, oviposition, egg hatch and adult emergence:

Per cent adult mortality and oviposiiion of *C. chinensis* on green gram treated with various oils is presented in Table 1. All the treatments except that of *N. sativa* at both the concentrations significantly reduced oviposition in comparison to controls. There was no significant difference between the two concentrations of the oils except for that of *B. longifolia*. Per cent adult mortality in *A. calamus* oil at the lower concentration was 42% after one day exposure and all the adults died at the end of second day. After two days of exposure, oil of *C. amada* at the lower concentration and *C. copticum* at higher concentration gave 40 and 46 percent adult mortality respectively. Other oils did not exhibit any significant mortality as compared to control.

Results on the ovicidal activity of various oils are given in Table 2. All

TABLE 1. Effect of oil treatment on adult survival and oviposition of *Callosobruchus chinesis* L.

Oils	Concentration ml kg	% adult mortality after days: 1	2	7	* % Oviposition
Acorus calamus	0.00	0.00	6.00		100.00
	0.25	42.00	100.00		6.55
	0.50	70.00	100.00		6.11
				C D at 5%	1.99
Curcuma amada	0.00	2.00	17.00	84.00	100.00
	0.25	4.00	40.00	98.00	19.98
	0.50	4.00	50.00	100.00	19.67
				C D at 5%	5.72
Carum copticum	0.00	6.00	20.00	90.00	100.00
	0.25	10.00	26.00	100.00	58.22
	0.50	20.00	46.00	100.00	61.79
				C D at 5%	26.81
Bassia longifolia	0.00	0.00	2.00	90.00	100.00
	0.25	0.00	0.00	100.00	85.92
	0.50	0.00	0.00	100.00	65.62
				C D at 5%	10.38
Nigella sativa	0.00	0.00	10.00	90.00	100.00
	0.25	0.00	12.00	100.00	128.98
	0.50	0.00	6 00	100.00	68.59
					NS

* Values are percentage of control.
NS Not significant ($p > 0.05$).

TABLE 2. Percent egg hatch and *emergence of *C. chinensis* L. on green gram treated with various oils.

Oils	Dosage in ml/kg			C D at 5%
	control	0.25	0.50	
Acorus calamus	98.18[a]	16 25[b]	9.66[b]	9.05
	(100.00)	(0.00)	(0.00)	—
Curcuma amada	97.04[a]	28.22[b]	30.12[b]	12.40
	(98.28)[a]	(70.20)[b]	(64.73)[b]	(25.78)
Carum copticum	94.60[a]	34.92[b]	13.39[c]	14.07
	(92.44)	(80.00)	(77.33)	(22.02)
Bassia longifolia	98.17[a]	34.67[b]	3.69[c]	3.33
	(100.00)	(92.04)	(78.64)	(21.72)
Nigella sativa	96.94	94.67	91.67	9.87
	(97.77)	(99.20)	(92.59)	(7 53)

* Figures in parentheses represent adult emergence calculated as percentage of hatched eggs.
Analysis done for horizontal rows only.
Figures with same or no alphabetical letter do not differ significantly ($P > 0.05$).

the oils except that of *N. sativa* significantly reduced the egg hatch on green gram. *C. copticum* and *B. longifolia* at both the concentrations showed significant difference; however, concentration had no effect in case of *A. calamus* and *C. amada* oils. Microscopic examination of the unhatched eggs revealed that majority of the eggs were killed at the very early stages of their embryonic dexelopment.

Oil of *A. calamus* and *C. amada* at both the concentrations significantly reduced the expected adult emergence; however, other oils had no effect on the adult emergence (Table 2).

Repellent action of oils:

Results on the repellent action of four oils against the bruchid adults are included in Table 3. In general the number of adults visiting the treated grains was far less than control, except for *C. amada.* Hence the egg deposition was reduced in treated grains in comparison to controls. Adult emergence was slightly affected in treatments of *C. copticum* and *B. longifolia* only.

Effect of oil treatments on grain damage after prolonged period:

Protective efficacy of various oils expressed on the basis of % damage is presented in Table 4. Results indicated that all the oils even at 1 ml/kg seed completely reduced the damage after 45 days. However, in case of *N. sativa,* only higher concentration of 2 or 5 ml/kg was effective. After 90 days, oils of *A. calamus, C. amada* and *C. copticum* effectively reduced the damage, while *B. longifolia* oil was effective only at the highest concentration tested. The oil of *A. calamus* was found to be the best, as even at 1ml/kg seed, it offered complete protection to green gram after 135 days. Other oils, however,

TABLE 3. Repellent action of selected oils against *C. chinesis* L. adults.

Oil	Concentration ml/kg	No. of insects counted	% of egg deposition	% of adult emergence
C. copticum	Control	55	100.00	84.3 9
	0.25	7	6.72	46.86
	0.50	15	4.86	71.50
C. amada	Control	35	100.00	86.86
	0.25	27	72.34	82.88
	0.50	33	83.53	85.40
N. sativa	Control	61	100.00	84.04
	0.25	13	21.06	86.80
	0.50	7	10.23	79.11
B. longifolia	Control	62	100.00	85.28
	0.25	18	23 71	80.49
	0.50	14	11.97	50.04

Values are averages of two sets.
Egg deposition is calculated as percentage of control.
Adult emergence is percentage of total eggs laid.

TABLE 4. Efficacy of extracted oils for a prolonged period against *C. chinensis* L, attack.

Oil Treatment	Dosage ml/kg	*Per cent damage to green gram after days: 45	90	135
A. calamus	0.0	27.50	65.75	99.25
	1.0	0.00	0.00	0.50
	2.0	0.00	0.00	0.25
	5.0	0.00	0.00	0.20
C. amada	0.0	33.50	68.50	99.25
	1.0	0.00	7.00	39.75
	2.0	0.00	3.75	27.50
	5.0	0.00	3.00	16.75
C. copticum	0.0	34.50	68.50	100.00
	1.0	0.00	7.25	70.25
	2.0	0.00	6.75	55.00
	5.0	0.00	0.00	18.75
B. longifolia	0.0	27.50	67.85	99 25
	1.0	2.15	50.75	82.75
	2.0	0.40	34.00	65.25
	5,0	0.00	2.25	37.75
N. sativa	0.0	37.25	75.50	97.00
	1.0	15.00	65.75	85.50
	2.0	1.00	36.75	65.00
	5.0	0.00	20.25	57. 50

* All values are average of three replicates.

showed decreased effectiveness towards the end of the experiment and the damage increased progressively.

It was confirmed from the germination test that oil treatment even at 5 ml/kg seed did not affect the viability of the grains to any significant extent. Average per cent germination recorded for green gram treated with the highest concentration of various oils was *A. calamus*, 95; *C. amada*, 91; *C. copticum*, 88; *B longifolia*, 85; *N. sativa*, 90; and control, 95.

Contact toxicity trials of some promising oils to *C. chinensis* adults on non-sorptive glass surface yielded the following results. Oil of *A. calamus* with an LD_{50} value of 1.42 µg/sq cm was the best followed by oils of *C. amada* and *C. copticum* for which LD_{50} values were 16.75 and 78.32 µg/sq cm respectively.

DISCUSSION

With the exception of *N. sativa* oil, all the other treatments significantly reduced oviposition on green gram. The reduced oviposition in oils of *A. clamus*, *C. copticum* and *C. amada* could be attributed mainly to their contact toxicity to the bruchid adults. However, no possible reason could be given for the reduced oviposition in oil of *B. longifolia* except for its slight repellent action to adults. SCHOONHOVEN (1978) has also reported the reduction in oviposition of *Zabrotes subfasciatus* (Boheman) on beans treated with cottonseed (crude) and African palm oils which was due to high adult mortality.

All the treatments except that of *N. sativa* exhibited significant ovicidal activity even at the lowest concentration. Ovicidal activity was best exhibited by oil of *B. longifolia* at 0.5 ml/kg level followed by *A. clamus*, *C. copticum* and *C. amada* oils. Such activity of *B. longifolia* oil has been reported against *C. chinensis* on red gram by SANGAPPA (1977). Ovicidal properties of a few vegetable oils like groundnut, coconut, cottonseed, palm, sesame, mustard and maize oils have been reported by MUMMIGATTI & RAGHUNATHAN (1977); SINGH *et al.* (1978); SCHOONHOVEN (1978); VARMA & PANDEY (1978); PEREIRA (1983) and MESSINA & RENWICK (1983). Almost all the above mentioned oils at 1, 2, 3 or 10 ml/kg seed have been reported to kill the bruchid eggs at their very early stages of embryonic development. Majority of authors expressed their views that the ovicidal nature of oils may be due to physical properties of the oils to block the oxygen supply for the developing embryo or due to the toxicity of some constituents of the oils tested. However, in the present investigation regarding the ovicidal properties of oils from medicinal plants, much lower concentrations were tested and found effective.

None of the oils screened could reduce the expected adult emergence at the tested dosage except in *A. calamus* oil, where no adults emerged even at 0.25 ml/kg. However, no conclusion could be drawn as percentage oviposition and egg hatch was very low in the particular oil treatment. This indicated that the oils at the tested concentrations exhibited ovicidal effect only in the early stages of embryonic development. This was confirmed from the microscopic examination of the unhatched eggs.

When choice was given between treatments and controls, the reduced oviposition in treated seeds compared

to controls was due to the repellent action of these oils to adults of *C. chinensis*.

Results on the prolonged protection offered by different oils at higher concentrations of 1 to 5 ml/kg seed showed that *A. calamus* oil at 1 ml/kg seed significantly reduced the grain damage after 135 days. Good protection offered by oil of *A. calamus* is mainly because of its insecticidal activity which was observed even at a dosage of 0.25 ml/kg seed. This was also confirmed in a separate experiment wherein oil was found to be potent contact poison against the bruchid adults. Insecticidal activity of *A. calamus* extracts against a few insect pests have also been reported by MIRONOV (1940) and DIXIT *et al.* (1956). Protective efficacy of *C. amada* and *C. copticum* oils for 90 days is by a combination of reduced oviposition and egg hatch. The reduced oviposition was mainly due to their contact action which was confirmed from sseparate contact toxicity tests. Oil of *B. longifolia* however, was ovicidal at lower concentrations but at higher concentration of 5 ml/kg seed, it might have exhibited insecticidal as well as ovicidal activity. SANGAPPA (1977) and ALI *et al.* (1983) have also reported the efficacy of this oil against the developing stages of *C. chinensis*. Oil of *N. sativa* at 2 or 5 ml kg showed some effectiveness upto 45 days but was less effective thereafter. The slight efficacy shown by this oil is possibly becacuse of its insectididal activity reported by DESHPANDE *et al.* (1974) wherein the authors found oleic and linoleic acids to be responsbile for its contact toxicity. Promising oils from the present investigation can be effectively used to protect green gram seed for prolonged periods from the bruchid attack as these are known to be safe having medicinal properties (NADKARNI, 1954).

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TOXICITY AND IRRITABILITY OF K-OTHRINE AGAINST FOUR SPECIES OF MOSQUITOES

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Laboratory tests performed on the larvae and adults of four species of mosquitoes, viz., *Aedes aegypti* Linnaeus, *Culex quinquefasciatus* Say, *Anopheles stephensi* Liston and *Anopheles culicifacies* Giles with a synthetic pyrethroid, K-Othrine (Deltamethrine) indicated high larvicidal and adulticidal activities of the insecticide against all the species of mosquitoes. Among them, the larvae of *Cx. quinquefasciatus* and the adults of *An. culicifacies* were found to be the most susceptible. The females of all the four species exposed to K-Othrine showed irritant behaviour evinced by increase in flight activity as compared to controls. The available evidence suggests that K-Othrine can be used as a very effective mosquito control agent.

(Key words: toxicity, irritability, K-Othrine, deltamethrine, mosquito, *Aedes aegypti, Culex quinquefasciatus, Anopheles stephensi, Anopheles culicifacies)*

INTRODUCTION

The propensity for mosquitoes to evolve resistance to conventional insecticides in different parts of the world has necessitated the search for more effective alternative insecticides. In this respect, synthetic pyrethroids have proved to be highly attractive for use in the field of agriculture and public health because of their environmental stability, low mammalian and high insect toxicity (ELLIOTT *et al.*, 1978). Among the many synthetic pyrethroids synthesized so far, K-Othrine (Deltamethrine, OMS 1998) has been considered to be a possible candidate insecticide, valuable in mosquito abatements. COOSEMANS & SALES (1977) reported satisfactory persistence of K-Othrine on mud thatch and wooden surfaces and it was found to be irritating to mosquitoes. The objective of the present studies was to determine the toxicity of K-Othrine to the Indian strains of *Aedes aegypti*, *Culex quinquefasciatus*, *Anopheles stephensi* and *An. culicifacies* and also to assess the irritability behaviour of the adult mosquitoes towards this insecticide.

MATERIALS AND METHODS

Mosquito colonies of *Ae. aegypti*, *Cx. quinquefasciatus*, *An. stephensi* and *An. culicifacies* were established in an insectary from field collected adults or larvae (BAKSHI *et al.*, 1982; BHASIN *et al.*, 1984; CHITRA & PILLAI, 1984). The colonies were maintained at 28±1°C and 80±5% R H with a photoperiod of 14 h of day light and 10 h of darkness. The larvae were fed on powdered dog biscuits and yeast in the ratio of 3:2. Adults were fed on water soaked split raisins. Females were given blood meal on alternate days by keeping restrained albino rats, in the cages, overnight.

The insecticide K-Othrine-(S)-α-cyano-3-phenoxyl-benzyl *cis*-(1R)-3-(2, 2-dibromovinyl)-2, 2-dimethyl cyclopropane carboxylate-technical grade 98.8% pure was supplied by Roussel Uclaf, India.

Larval susceptibility tests were performed on early fourth instar larvae according to WHO method for mosquito larvae (WHO, 1981a). Ethanolic solutions of insecticide was used in the treatment. The tests were carried out at 28±1°C. Mortality counts were taken 24 h after the treatment. Each test had 4 replicates. Percentage mortalities were corrected by Abbott's formula. The mortality data was subjected to computer analysis for the regression of probit mortality on log dosage on IBM computer system 360/44 and the LC_{50} and LC_{90}, slope and heterogeniety (X^2) of the linear regression line were computed.

The adult susceptibility tests were performed using the standard method for testing adult susceptibility (WHO, 1981b). Freshly blood-fed 3 day-old adult female mosquitoes were exposed for different time intervals to 0 025% K-Othrine-impregnated papers (supplied by Roussel Uclaf, France) and the mortality was recorded after 24 h. The LT_{50} and LT_{90} values were calculated by computer analysis of the mortality data.

Adult irritability test was performed by the tentative WHO method (1960) as modified by BHATIA & DEOBHANKAR (1962). Three-day-old freshly blood-fed female mosquitoes were used for the test. K-Othrine-impregnated paper (0.025%) was kept on a glass plate and the perspex funnel was fixed on it. One mosquito was released at a time into the funnel. The time for the first take-off of the single mosquito after the 3-min settling time was recorded. The actual figure recorded was the time from the initial introduction (i.e., Z+3 rather than Z). During the following 15 min the mosquito was observed and the number of take-offs from the K-Othrine-impregnated paper was recorded. Similar control tests were performed with oil-impregnated papers. Each test had 25 replicates with parallel controls.

RESULTS

Larval susceptibility data are presented in Table 1. In general K-Orthrine was found to be highly toxic to the larvae of all the four species of mosquitoes tested as the larval LC_{50} levels ranged from 0.166 to 2.457 ppb. Among the four species tested *Cx. quinquefasciatus* was the most susceptible while *An. stephensi* proved to be the least susceptible.

Similarly, the female adult mosquitoes were highly susceptible to K-Othrine. Among the mosquitoes *An. culicifacies* was the most susceptible with an LT_{50} value of 1.267 min while *Cx. quinquefasciatus* showed an LT_{50} value of 11.452

TABLE 1. Larval LC_{50} and LC_{90} levels (in ppb) with fiducial limits of four species of mosquitoes exposed to K-Othrine.

Species	LC_{50}	LC_{90}	Slope	Heterogeneity X^2
Ae. aegypti	0.172 0.146—0.20	0.46 0.408—0 533	4.455	10.46*
Cx. quinquafasciatus	0.166 0.132—0.204	0.404 0.341—0.505	5.387	17.66*
An. stephensi	2.457 1.551—4.291	5.357 3.763—10.190	0.442	138.91*
An. culicifacies	0.337 0.070—0.573	1.259 0.918—2.168	1.390	75.16*

*Degrees of freedom—10.

min (Table 2). The LT_{50} values for *Ae. aegypti* and *An. stephensi* were 7.028 min and 6.729 min respectively.

The results of irritability tests are given in Table 3. When-three-day-old blood fed females were exposed to K-Othrine papers, the time elapsing from the first take-off showed an average of 3.2 to 4.1 min for the different species while in the control tests it ranged from 5.5 to 14.0 min. Among the different species of mosquitoes there was no significant difference in the mean time-lapse before the first take-off. The average number of take-offs per female for a period of 15 min from the insecticide impregnated paper for different species of mosquitoes was 16–21 as compared to an average of 1.2–7 take-offs on the control paper. *An. culicifacies* showed minimum number of

TABLE 2. LT_{50} and LT_{90} values (in min) with fiducial limits of adult females of four species of mosquitoes exposed to 0.025% K-Othrine-impregnated paper.

Species	LT_{50}	LT_{90}	Slope	Heterogeneity X_2
Ae. aegypti	7.028 5.311—9.586	15.864 12.462—22.681	0.145	26.42*
Cx. quinquefasciatus	11.452 5.589—15.345	28.215 22.488—38.843	0.076	24.78*
An. Stephensi	6.729 1.627—11.272	40.199 31.538—56.442	0.038	19.28*
An. culicifacies	1.267 1 184—1.337	1.901 1.797—2.047	2.021	2.996*

*Degrees of freedom—8.

TABLE 3. Responses of 3-day old blood-fed female mosquitoes in irritability tests when exposed to 0.025% K-Othrine impregnated papers.

	Mean time lapse before first take-off (in min)				Mean number of take-offs per female (in 15 min)			
	Control		K-Othrine		Control		K-Othrine	
	Range	Mean ± S E	Range	Mean ± S E	Range	Mean ± S E	Range	Mean ± S E
Ae. aegypti	3.1–18.0	5.5±0.72	3.0–3.5	3.2±0.03	0–17.0	7 0±0.93	6.0–45 0	20.7±2.01
Cx. quinquefasciatus	3.3–18.0	8.7±1.13	3.0–7.5	4.1±0.22	0– 7.0	2.5±0.44	11.0–42.0	20.5±1.58
An. stephensi	3.1–18.0	12.7±1.21	3.0–5.1	3.4±0.11	0– 5.0	1.2±0.28	6.0–35.0	21.1±1.55
An. culicifacies	3.4–18 .0	14.0±1.06	3.0–4.4	3.4±0.07	0– 8.0	1.4±0 38	4.0–25.0	16.0±0.86

average take-offs while the other species had more or less the same number of average take-offs. The adults of *An. culicifacies* showed less number of flight take-offs as these adults succumbed to the knock down effect of the insecticide in less than 15 min. The results indicate that female mosquitoes were sensitive to irritability caused by K-Othrine as they took lesser time for the first take off. Mosquitoes exposed to K-Othrine papers also showed greater flight activity during the 15 min period than shown by the mosquitoes on the control papers.

DISCUSSION

The pyrethroids are known to exert high toxicity to insects. The present data convincingly indicate the bioefficacy of K-Othrine as an excellent insecticide suitable for mosquito control programmes. K-Othrine is proved to be extremely toxic as larvicide and adulticide against four species of mosquitoes. It is remarkable to note that very low concentrations of K-Othrine are effective against larvae and adults. Similarly K-Othrine was found to be the most effective among the several synthetic pyrethroids tested as larvicides in experimental ponds containing a mixture of *Cx. tarsalis, Culiseta inornata* and *An. franciscamus* (MULLA *et al.*, 1978). Also K-Othrine proved to be effective in inflicting complete larval mortatity in a multiresistant *Ae. nigromaculis* strain (MULLA *et al.*, 1978). This pyrethroid was found to be 600 times as active as DDT to *An. stephensi* (BARLOW *et al.*, 1987). The present data also indicate highest larvicidal activity of K-Othrine against *Cx. quinquefasciatus*. Similar findings have been reported by PRIESTER *et al.* (1981).

The present studies also indicate that K-Othrine has irritant and probably repellent action. The irritant effect of this insecticide could produce exophily in mosquitoes and thus reduce man-mosquito contacts. In Upper Volta it was found that sizeably less female mosquitoes enter the K-Othrine treated house (COOSEMANS & SALES, 1977). BARLOW *et al.* (1977) reported that the contact toxicities of *An. stephensi* on the sprayed deposits of several pyrethroids including K-Othrine were lower than predicted from topical results, possibly because irritant and repellent actions and the physical state of the toxicant diminished the dose acquired by insects. However, suitable formulations devoid of these deficiencies should make pyrethroids valuable for malaria control (BARLOW *et al.*, 1977).

The present results and the results of field studies aeported elsewhere clearly suggest that K-Othrine could be used as an effective substitute insecticide in malaria control in specific and mosquito conrtol in general.

Acknowledgements: We are grateful to Roussel Uclaf, India for providing the synthetic pyrethroid K-Othrine. One of us (AT) is thankful to CSIR for awarding a Junior Research Fellowship.

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DROSOPHILA PARAIMMIGRANS, A NEW SPECIES FROM SOUTH KANARA, INDIA (DIPTERA : DROSOPHILIDAE)

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(Received 4 December 1984)

Faunistic surveys of *Drosophila* were made from Charmadi Ghats of South Kanara District. A new species of *Drosophila* has been identified, which is a member of the *immigrans* group of subgenus *Drosophila*. It has been named and described as *Drosophila paraimmigrans*. Its taxonomic status and relationships are discussed.

(Key words: Drosophila paraimmigrans, new species, *immigrans* group)

The Western Ghats with its varied flora offers a rich variety of insect species. In the recent past, several workers have made faunistic surveys in different regions of the Ghats resulting in descriptions of several species of Drosophilidae (Reddy & Krishnamurthy, 1971, 1974; Ranganath & Krishnamurthy, 1972; Siddaveera Gowda & Krishnamurthy, 1972; Vaidya & Godbole, 1971, 1972, 1973, 1976; Prakash & Reddy, 1978a, 1978b, 1978c, 1980; Hegde & Krishnamurthy, 1980; Nagaraj & Krishnamurthy, 1980; Muniyappa & Reddy, 1980, 1982). Even so, several distinct tracts in the hills remain unexplored and must be the abode of a considerable variety of these dipterans. One such tract is the Charmadi Ghat in South Kanara District (12°25′ and 13°58′ North latitude and 74°35′ and 74°40′ East longitude) and a survey of of this region revealed the presence of a hitherto unknown species. This communication deals with a detailed description of this new species.

Drosophila paraimmigrans: sp. nov. (Figs. 1–7)

Male and *Female:* Large brown flies.

Body length: Male 3.32 mm, Female 3.32 mm.

Head ♂ and ♀: Arista with 12 branches (5/7) including terminal fork. Frons brown. Antennae dark brown. Cheek with two vibrassae. Carina broad with few bristles. Palpus brown with a single straight bristle. Orbital bristles in the ratio of 2:1:1. Inner and outer verticals of same length and reclinate. Ocellar triangle small with 2 long bristles. Eyes red.

Thorax ♂ and ♀: Brown, Acrostichal hairs regular, in 8 rows. Anterior dorsocentral half the length of posterior. Scutellum light brown. Anterior scutellars convergent; posterior scutellars convergent and crossed. Prescutellars absent.

Wings ♂ and ♀; Smoky. Wing length 2.55 mm (male) and 2.70 (Female).

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	C–index	4V–index	4L–index	5X–index	M–index
Male	4.46	1.21	0.50	0.82	0.27
Female	4.35	1.23	0.52	0.89	0.30

Third costal section with heavy setation on basal 0.6 (Wing indices calculated after Okada, 1956 and Bock, 1976). Halteres pale brown.

Legs: Preapical bristles on all tibiae, apicals only on 2nd tibia. A row of thick peg like bristles (cuneiform) on the inner side of the first femur. Sex comb absent (Fig.1).

Abdomen ♂ and ♀: The tergites of both the sexes are brown.

Periphallic organs (Fig. 2). Epandrium very broad dorsally. Toe with 11 bristles not covering primary surstylus. Heel not pronounced, with 3 bristles. Primary surstylus present with 14 stout black teeth arranged in a concave row. 3 elongated brownish bristles present on inner side of the teeth on the primary surstylus. Primary surstylus with a cluster of bristles on the inner margin pointing towards the ventral margin of the cercus. Secondary surstylus absent. Cercus more or less oblong and pubescent bearing 30 bristles. Cercus independent of primary surstylus and in addition bears 6 pointed teeth towards the ventral margin.

Fig. 1. Fore leg of male showing cuneiform bristles.

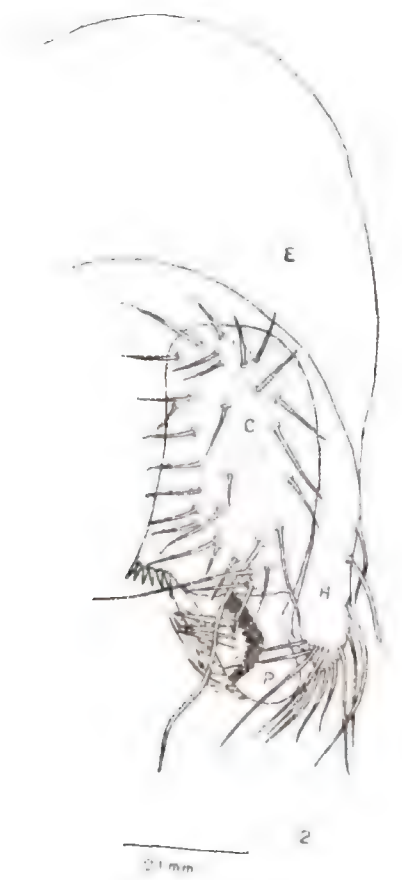

Fig. 2. Periphallic organs: C = Cercus; E = Epandrium; H = Heel; P = Primary surstylus

Phallic organs (Fig. 3): Aedeagus pointed, cone shaped, non-bifid. Basal apodeme projects beyond ventral fragma. Anterior gonapophyses elongated and cylindrical. Posterior gonaphyses long, reaching tip of aedeagus. Caudal margin of novasternum concave bearing 6 short and 2 long spines. Ventral fragma broad with a spine arising at the base of novasternum.

Egg guide (Fig. 4): Pale yellow with 17 median teeth and 10 marginal teeth.

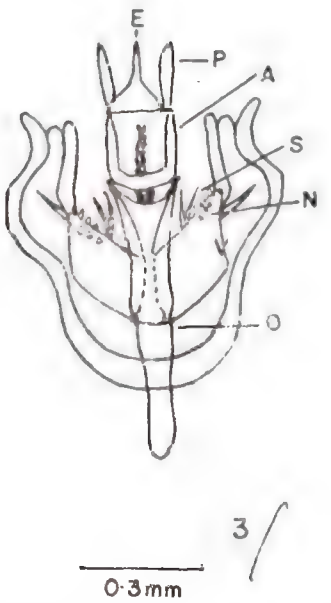

Fig. 3. Phallic organs: A = Anterior gonapophyses; E = Aedeagus; N = Novasternum; O = Basal apodeme; P = Posterior gonapophyses; S = Submedian spine of novasternum; V = Ventral fragma.

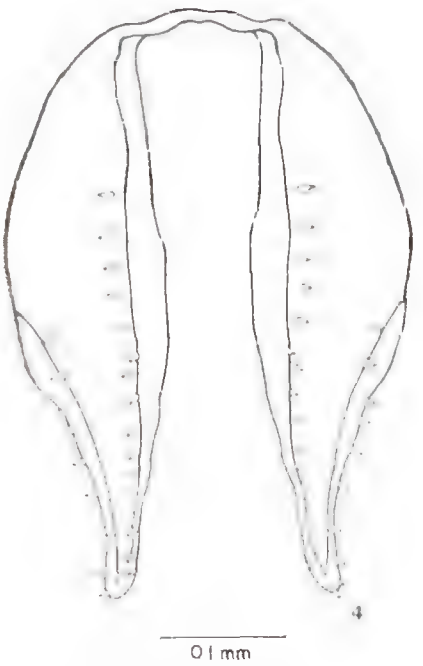

Fig. 4. Egg guide.

Internal structures: Testis (Fig. 5), Orange with coils. Accessory gland medium and transparent. Ejaculatory bulb oval. Spermatheca (Fig. 6) round. Paraovaria large and round. Ventral receptacle with severel coils. Malpighian tubules two and fused.

Egg filaments: (Fig. 7), Four long slender filaments with tapering ends.

Pupa: Anterior spiracle with 25 branches arranged in a rosette like manner.

Distribution: INDIA, KARNATAKA, South Kanara District, Charmadi Ghats (Western Ghats).

Holotype ♂: INDIA, KARNATAKA: Charmadi ghats, South Kanara District,

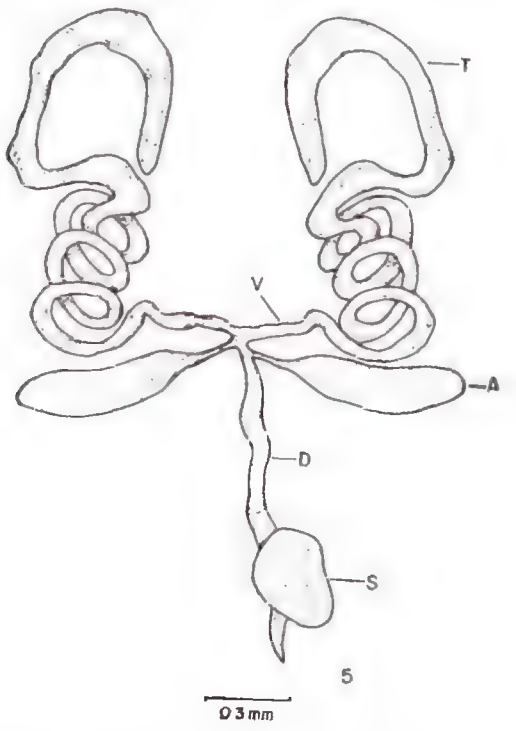

Fig. 5. Male reproductive organs: A = Accessory gland; D = Anterior ejaculatory duct; S = Ejaculatory bulb; T = Testis; V = Vas deferens.

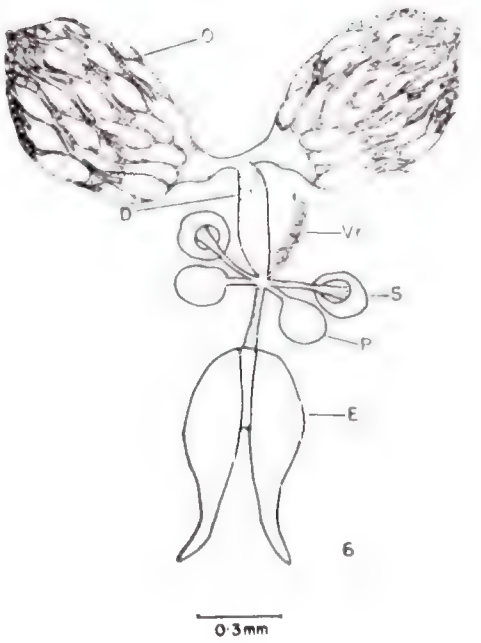

Fig. 6. Female reproductive organs: E = Egg guide; D = Oviduct; O = Ovary; P = Paraovaria; S = Spermatheca; Vr = Ventral receptacle.

Fig. 7. Egg.

7×72. Colls. P. G. Gai, N. B. Krisnamurthy, S. N. Hegde. **Paratypes:** 12 ♂♂ and 8 ♀♀: same data as holotype. The holotype and some paratypes deposited in the Department of Zoology, University of Mysore, Manasagangotri, Mysore. 4 ♂♂ and 3 ♀♀ are deposited in the Department of Biology, Tokyo Metropolitan University, Setagaya-ku, Tokyo, Japan.

Relationships and Remarks: The presence of 4 egg filaments with tapering ends and testis with 4 coils justifies its inclusion in the subgenus *Drosophila* (Patterson and Stone, 1952). A row of 10 short thick peg like bristles (cuneiform) on the inner side of the first femur; heel not very pronounced; toe pointing downward and not covering primary surstylus; cerci oblong; presence of only primary surstylus with a single concave row of of teeth warrants the inclusion of this species in the *immigrans* species group (Hsu, 1949; Okada, 1956; Wilson *et al.*, 1969).

Okada (personal communication, December, 1982) has pointed out that the new species belongs to the *immigrans* species group. A unique feature of this new species is that the epandrium is very broad towards the dorsal side of the cercus, which is not found in any other members of this group. On comparison with other members of the *immigrans* group, it shows resemblance to *D. immigrans* in having a heel not very pronounced; pointed toe; protruded primary surstylus and also in the arrangement of teeth on the primary surstylus. It also resembles *D. immigrans* in the structure and number of coils of the testis; in the shape and size of the spermathecae and paraovaria (Throckmorton, 1962). Hower, it distinctly differs from *D. immigrans* in the absence of pigmentation at the posterior tip of abdomen of males. The presence of 11 long bristles on toe, 14 black stout teeth on primary surstylus, cluster of bristles on the inner margin of primary surstylus pointing towards ventral margin of cerci and an oblong pubescent cercus with about 30 bristles demands an independent status for this new species. This species is named as *Drosophila paraimmigrans*.

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THREE NEW SPECIES OF NOTHOPODINAE (ERIOPHYIDAE : ACARI) FROM TAMIL NADU

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(Received 19 October 1984)

The paper presents the descriptions of three new species of Nothopodine mites, viz., *Disella vagrans*, sp. nov., *Disella granulacoxae*, sp. nov. and *Neocolopodacus muruganii*, sp. nov.

(Key words: Eriophyidae; Nothopodinae, *Disella*, *Neocolopodacus)*

In the course of survey and collection of phytophagous mites from Tamilnadu, three new species of Nothopodinae mites were encountered and the same described below, with adequate figures.

The type and paratype slides have been deposited in the collections of the Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore-641 003, India.

1. Disella granulacoxae sp. nov. (Fig. 1)

Female: 160[1] long, 50 thick; rostrum 10 long, down curved, antapical seta 4 long; shield 40 wide, 30 long; median complete; admedians complete, wavy, converging anteriorly; submedians represented by short strokes; sides of shield granular; dorsal tubercles just away from rear shield margin, 20 apart; dorsal setae 16 long, pointing backwards and outwards. Foreleg 17 long, tibia 2 long; tarsus 4 long, claw 4 long, pointing on the inner lateral angle; featherclaw 4–rayed; hind leg 17 long, tarsus 4 long, claw 7 long in normal dorsal position; femoral seta and patellar seta present on both legs. Coxae broadly joined, first setiferous coxal tubercles absent; coxal area coarsely granular. Abdomen with about 65 rings uniformly microtuberculate, microtubercles more elongated dorsally and dot like ventrally; lateral seta 20 long on ring 10; first ventral setae 48 long on ring 22; second ventral seta 8 long on ring 38; third ventral seta 18 long on ring 7 from behind; caudal seta 50 long; accessory seta dot like. Female genitalia 22 wide, 14 long; coverflap coarsely granular and with cressentric scorings distally; genital seta 2 long.

Male: Unknown.

Types: A holotype slide and 4 paratype slides, all with ♀♀; INDIA: Tamilnadu: Madurai, Alacarmalai, 9.vi.1984. ex *Thespesia lamps.* Dalz & Gibs (Malvaceae); M. Mohanasundaram Coll. (No. 514) (TNAU). The mites produce erineum patches on the leaf surface.

[1] All measurements are in μm.

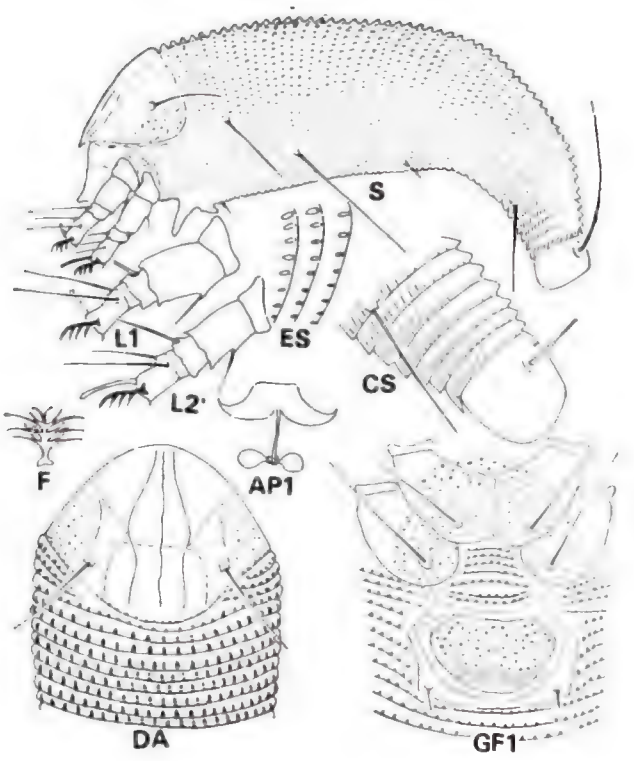

Fig. 1. *Disella granulacoxae* sp. nov. API—Female internal apodeme; CS—Side view of caudal end; DA—Dorsal view of anterior end; ES—Side skin structure; F—Featherclaw; GFI—Female genitalia and coxae from below; GM—Genitalia of male; L1—Left foreleg S—Side view of mite.

2. Disella vagrans, sp. nov. (Fig. 2)

Female: White, 140 long, 50 thick, rostrum 10 long, evenly down curved; antapical seta 3 long. Shield 40 wide, 32 long, median nearly complete admedians complete, wavy with cross lines joining at three points with the median; submedians represented in the anterior end; anterior shield margin with cells, sides of shield with scorings; dorsal tubercles away from rear shield margin, prominent; 22 apart; dorsal setae 10 long pointing backwards. Foreleg 17 long; tibia 2 long; tarsus 4 long, claw 4 long on the inner lateral angle; featherclaw 4 rayed; hind leg 15 long, tarsus 5 long; claw 6 long in normal dorsal position; both legs with femoral, patellar and tarsal setae. Coxae with the first setiferous tubercles absent. Coxal area smooth. Abdomen with about 55—60 rings; microtuberculate ventrally; lateral seta 16 long on ring 8; first ventral seta 35 long on ring 18; second ventral seta 8 long on ring 30; third ventral seta 20 long on ring 8 from behind; caudal seta 20 long; accessory seta absent. Female genitalia 22 wide, 13 long; coverflap granular with cressentric scorings distally; genital seta 5 long.

Male: Unknown

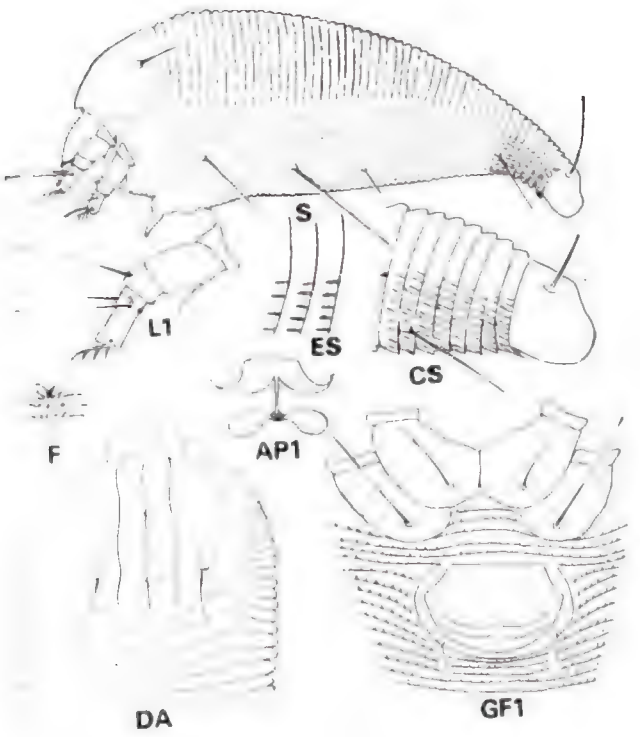

Fig. 2. *Disella vagrans* sp. nov. (For abbreviations used, see Fig. 1)

Types: A holotype slide and 3 paratype slides, all with ♀♀; INDIA: Tamil Nadu: Madurai, Alagarmalai, ex *Waltheria indica* L. (Sterculiaceae) 9.vi.1984. M. Mohanasundaram Coll. (No. 507) (TNAU). The mites are under surface leaf vagrants.

Remarks: Both species resemble *Disella ilicis* (Keifer) (1965) in its shield pattern but differentiated from it by the 4 rayed featherclaw, and granular genital cover flap with cressentric lines. They are also differentiated from *Disella talisae* (Keifer) (1969) by the longer and backward pointing dorsal setae and the granular genital coverflap with cressentric lines.

KEY TO THE SPECIES OF *DISELLA* NEWKIRK AND KEIFER (1975)

1. Featherclaw 4 rayed..... 2
—Featherclaw 5 rayed, coxal area wrinkled, tergites smooth..... *ilicis* Keifer (1965)
2. Foreclaw in normal dorsal position pointing forward..... 3
—Forclaw on the inner lateral position pointing diagonally inward..... 4
3. Coxal area granular, coverflap with longitudinal lines..... .....*tectonae* Das and Chakrabarti (1982)
—Coxal area smooth, coverflap, with curved transverse lines..... .....*talisiae* Keifer (1969)
4. Coxal area and genital coverflap, coarsely granular, tergites with microtubercles..... .....*granulacoxae*, sp. nov.
—Coxal area smooth, genital coverflap with fine granulations; tergites smooth..... .....*vagrans* sp. nov.

3. Neocolopodacus muruganii, sp. nov. (Fig. 3)

Female: 140 long, 65 thick; rostrum 16 long, evenly down curved, antapical

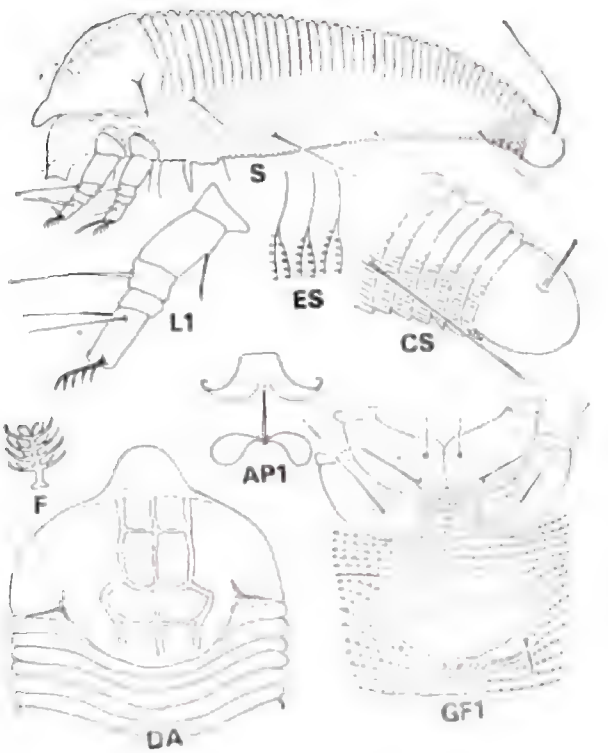

Fig. 3. *Neocolopodacus muruganii* sp. nov. (For abbreviations used, see Fig 1.)

seta 4 long. Shield 55 wide, 45 long; a broad lobe overhanging rostrum base separated by a transverse furrow; with a pattern of thick lines; median complete, admedians complete, bent at the rear, with cross lines joining with the median at three points, submedians absent; sides of shield smooth; dorsal tubercles just away from rear shield margin, 45 apart dorsal seta 9 long pointing laterally. Foreleg 25 long, tibia 3 long, tibial seta absent; tarsus 7 long; claw 5 long, on the inner angle; claw 5 rayed; hind leg 18 long, tibia 2 long, tarsus 6 long; claw 7 long; all usual setation present. Coxae widely joined, all three coxal setiferous tubercles present; Coxal area granular. Abdomen with about 40 smooth tergites and 60 microtuberculate sternites; lateral seta 12 long on ring 12; first ventral setae 40 long on ring 25; second ventral seta 5 long on ring 38; third ventral seta 16 long on ring 7 from behind; caudal seta 45 long, accessory seta absent. Female genitalia 28 wide, 18 long, coverflap with 10-12 lines basally and distally smooth; genital seta 6 long.

Male: Unknown.

Types: A holotype slide and 4 paratype slides all with ♀♀; INDIA: Tamil Nadu: Madura, Alagarmalai near Murugan Temple, 9 vi.1984, ex *Grewia disperma*, Rottl. (Tiliaceae); M. Mohanasundaram Coll. (No. 511) (TNAU). The mites are under surface leaf vargants.

Remarks: The species resembles *Neocolopodacus mitragynae* Mohanasun-

daram (1980) in its granular coxal area and coverflap with longitudinal scorings but differentiated from it by the 5 rayed featherclaw, shield pattern and the dorsal setae pointing sidewards apart from the measurements.

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THREE NEW SPECIES OF RHYNCAPHYTOPTID MITES (RHYNCAPHYTOPTIDAE : ERIOPHYOIDEA) FROM TAMIL NADU.

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The paper presents the description of one new genus and three new species of Rhyncaphytoptid mites, viz., *Hyborhinus kallarensis* gen. et sp. nov. *Diptilomiopus alagarmalaiensis* sp. nov. and *Diptilomiopus maduraiensis* sp. nov.

(Key words: Eriophyoidea; Rhyncaphytoptidae, *Hyborhinus, Diptilomiopus)*

In the course of survey, collection and study of eriophyid mites, three new species of Rhyncaphytoptid mites were collected of which one belongs to a new genus. The mites have been adequately sketched and described.

The types and paratypes slides have been deposited in the collections of the Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore-641003, India (TNAU).

Hyborhinus gen. nov.

This genus resembles *Hyboderus* Keifer (1975) in its general shape, location of the dorsal tubercles in antero lateral position; shape of the abdomen and rostrum, but could be differentiated from it by the presence of the femoral and patellar setae on both legs; and the absence of the first pair of setiferous coxal tubercles. It also resembles *Catarhinus* Keifer (1959) in its short projection of shield over rostrum base; presence of the bent apical sensory seta at rostral tip, but differentiated from it by the presence of all leg setation; absence of the first coxal tubercles, more lateral position of the dorsal shield tubercles and the absence of the dorsal abdominal ridge and furrows. The new genus has the combination of characters of *Hyboderus* and *Catarhinus* and hence the name. The member of this genus also has the feature of production of clear secretion on its body while feeding on the leaf surface which has been noted in the case of *Hyboderus globulus* Mohanasundaram (1981 b.)

Robust, broadly spindle shaped, whitish species; rostrum large, tapering, pointing down and bent diagonally back under coxae with long form oral stylet; a short rostral seta at the base of rostrum, antapical seta prominent; apical sensory setae large and bent at apex. Shield semicircular in anterior outline with a short lobe over rostrum base; dorsal tubercles widely separated, prominent and directing setae anteriorly. Legs with all usual setation, tibiae long; featherclaw simple. Coxae well separated with a clear sternal line; first pair of coxal tubercles absent, second pair at

the base of fore coxae; third pair in normal position. Thanosome sharply divided along lateral line by strong microtubercles on sternites; tergites without microtubercles. All usual abdominal setation present. Female genitalia just away from coxal base and broad.

Type species: Hyborhinus kallarensis, sp. nov.

This genus is referable under Rhyncaphytoptinae.

1. Hyborhinus kallarensis sp. nov. (Fig. 1)

Female: White, broadly spindle shaped, 195—200[1] long, 70 wide, rostrum 30 long, down curved; antapical seta 10 long, 60 wide, sensory setae bent at apex. Shield semicircular anteriorly, 60 wide, 28 long, median absent, admedians represented in the anterior end as inverted U; submedian represented from base of dorsal tubercles and fading out anteriorly; sides of shield smooth; dorsal tubercles broad 7 long, 33 apart; dorsal setae 10 long, pointing forward. Foreleg 40 long tibia 14 long; tibial seta 12 long

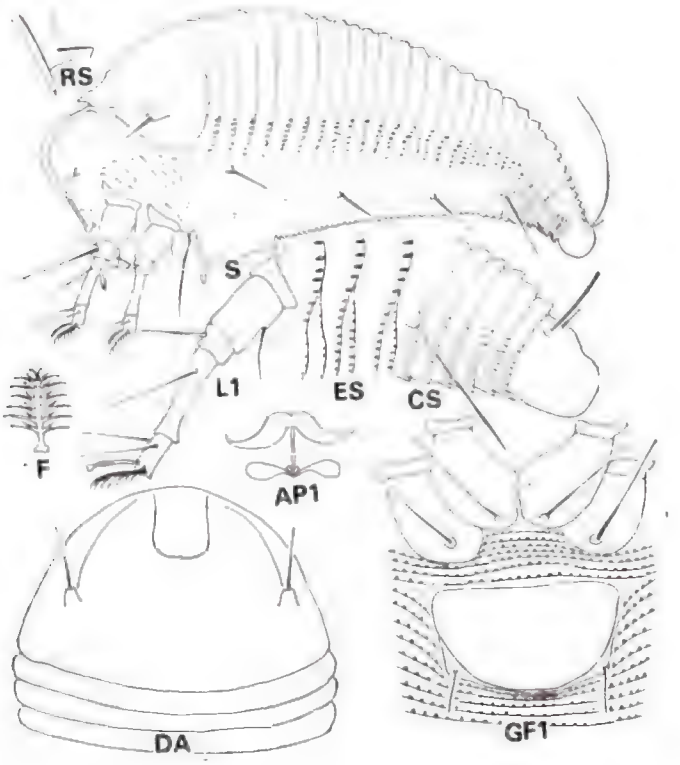

Fig. 1 *Hyborhinus kallarensis*, sp. nov.

AP1 — Female internal apodeme; CS — Side view of caudal end; Dorsal view of anterior end; ES — Side skin structure; F — Featherclaw; GFI — Female genitalia and coxae from below; GM — Genitalia of male; L1 — Left foreleg; RS — Rostral seta; S — Side view of mite.

[1] All measurements are in μ m.

at basal 1/3; tarsus 8 long; claw 8 long, slightly curved and knobbed at tip; feather claw 7 rayed, simple hind leg 35 long; tibia 12 long, tarsus 7 long, claw 8 long. Coxae widely separated with a clear sternal line, coxal tubercles I absent; II at base of fore coxae; III in the middle of hind coxae; coxal area smooth. Abdomen with about 30 smooth tergites and about 65 microtuberculate sternites; lateral seta 10 long on ring 15; first ventral seta 10 long on ring 30; second ventral seta 15 long accessory seta 2 long. Female genitalia just away from coxal base; 35 wide, 25 long, coverflap smooth; genital seta 8 long.

Male: Unknown

Types: A holotype slide and 5 paratype slides, all with ♀♀; INDIA: TAMIL NADU: Kallar, on the way to Fruit Research Station, 20. vii. 1984, ex. *Flacourtia ramontchi* L' Herit (Flacourtiaceae) M. Mohanasundaram Coll. (No. 523) (TNAU).

Remarks: The mites are under surface leaf vagrants producing a clear secretion on their body while feeding.

2. Diptilomiopus alagarmalaiensis, sp. nov. (Fig. 2)

Female: Light brown, spindle shaped, 185 long, 70 thick, rostrum 30 long, bent down; antapical seta 3 long; shield 60 wide; 27 long with a clear pattern of lines; median and admedian represented in the rear 1/3; anteriorly joined and bifurcate to form cells in the anterior shield area; dorsal tubercles at rear

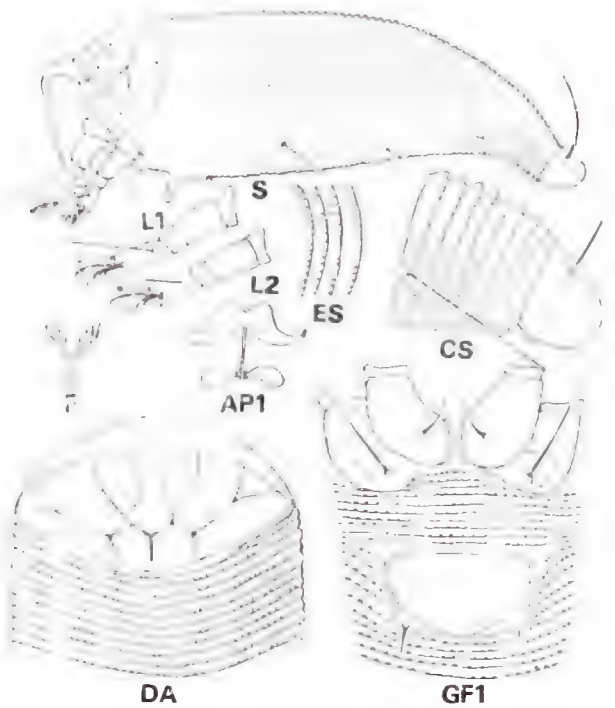

Fig. 2. *Diptilomiopus alagarmalaiensis* sp. nov.
(For abbreviations See Fig. 1.)

shield margin, minute, 25 apart, dorsal setae absent. Foreleg 30 long, tibiotarsus 9 long, claw 5 long, featherclaw divided with 4 rays in each; hind leg 25 long, tibiotarsus 9 long; claw 5 long; femoral and patellar setae absent on both legs, foreleg tibiotarsus with a pair of ong setae and hind leg tibiotarsus with one seta; coxae broadly joined, first coxal tubercles absent; coxal area smooth except for a few lines in the hind coxae. Abdomen with about 60 tergites and about 90 sternites with elongated microtubercles along with the posterior margin of each ring; lateral seta absent; first ventral seta 8 long on ring 40; second ventral seta 5 long on ring 60; third ventral seta 22 long on ring 9 from behind; caudal seta 25 long; accessory seta dot like; female genitalia 26 wide, 18 long; cover flap with basal fine scorings and distally smooth; genital seta 5 long.

Male: Unknown

Types: A holotype slide and 5 paratype slides, all with ♀♀; INDIA: TAMIL NNDU: Madurai, Alagarmalai, 9.vi.1984. ex *Spondias mangifera* Wild (Anacardiaceae) M. Mohanasundaram Coll. (No. 513) TNAU. The mites are under surface leaf vagrants.

Remarks: This species resembles *Diptiolomiopus bengalensis* Chakrabarti and Mondal (1979) in its shield pattern, but differentiated from it by the presence of shield tubercles, 4 rayed divided featherclaw; microtuberculate tergites, and short genital seta. It is also differentiated from *D. knorii* Keifer (1974)

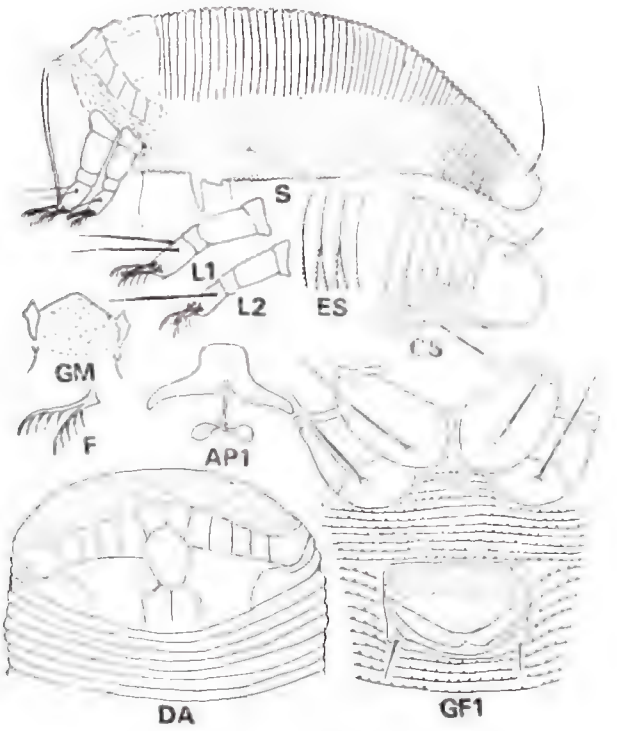

Fig.3 *Diptilomiopus maduraiensis* sp. nov.
(For abbreviations See Fig. 1.)

by featherclaw, shield anterior and shield pattern.

3. Diptilomiopus maduraiensis, sp. nov. (Fig. 3).

Female: Light brown, spindle shaped, 205 long, 70 thick, rostrum 30 long bent down with long form oval stylets, antapical seta 4 long; shield 60 wide, 25 long; with a pattern of cells forming the anterior margin and in the middle; dorsal tubercles minute, at rear shield margin, 18 apart; dorsal setae absent; foreleg 25 long, tibiotarsus 9 long; claw 5 long; feather claw divided with 5 rays in each; hind leg 23 long; tibiotarsus 9 long, claw 4 long, femoral and patellar setae absent in both legs; foreleg with two setae on tibiotarsus while the hind leg with one long seta on tibiotarsus; coxae broadly joined, first coxal tubercles absent coxal area smooth. Abdomen with about 52 tergites and about 70 sternites, lateral seta absent; first ventral seta 12 long on ring 20; second ventral seta 6 long on ring 40; third ventral seta 30 long on ring 7 from behind. Caudal seta 50 long; accessory seta absent. Female genitalia 23 wide, 17 long; coverflap basally granular and distally smooth; genital seta 4 long.

Male : 190 long, 65 thick, genitalia 18 wide, genital seta 4 long.

Types: A holotype slide with ♀♀; 4 paratype slide with ♀♀ and ♂♂: INDIA TAMIL NADU : Madurai, 9. vi. 1984. ex. *Alangium* sp. (Alangiaceae) M. Mohanasundaram Coll. (No. 512) TNA). The mites are under surface leaf vagrants.

Remarks : This species resembles *Diptilomiopus cameiae* Mohanasundaram (1981 a) in its general shield pattern but differentiated from it by the absence of two cells on either side of middle line; 5 rayed divided feather claw and smooth coxal area. It is also differentiated from *Diptilomiopus assamica* Keifer (1959) by the shield pattern, with only one row of cells; basally granular genital cover flap and clear smooth coxal area.

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STUDIES ON THE MECHANISM OF ACTION OF REPELLENT VAPOURS ON THE RATE OF INTACT COCKROACH HEART BEAT

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(Received 21 November 1984)

A new method was devised to measure the beating of an intact cockroach heart, stimulated with a repellent compound. Pulsation rate of an adult cockroach *Periplaneta americana* L. heart has been taken as a quantitative criterion for the physiological effect of the vapours of a synthetic repellent, dimethyl phthalate (DMP), Vapours passed through the insect antennae caused variance in the normal beating. The result on the response of the cockroach heart to different concentrations of repellent vapours varied with the concentration of the compound. Response of both the sexes were also varied. The heart of antennectomized cockroach was less sensitive.

(Key words: Periplaneta americana L, dimethyl Pthalate, corpora cardiaca, olfactory organs, chemoreception, antennectomy)

INTRODUCTION

It has long been known that the contraction of an insect heart is affected by variety of factors such as the general metabolism, stage of development and temperature. Addition of toxic compounds to the blood, causes variance in the normal beating of the insect heart. Use of heart rate measurements in behavioural research had been suggested by a number of workers (LACEY & LACEY, 1970). Pharmacology of the insect heart and circulatory reponse was taken as a criterion for mode of toxic action of compounds having insecticidal value (ORSER & BROWN, 1951). Many drugs and insecticides have been tested with respect to their modes of action on their rate of heart beat and other systems of the insects (NAIDU, 1959). However, very little information is available on the effect of vapours on the intact cockroach heart beat.

In the present investigation, the rate of pulsation of the heart of the adult cockroach was taken as a quantitative criterion of the physiological effect of the vapour of a synthetic repellent, i.e., dimethyl pthalate.

MATERIALS AND METHODS

The adult cockroaches reared in laboratory at 28 ± 1°C and 80 per cent relative humidity were chosen as test insects. The cockroach being fabundant and of large size, it has been possible to use it as an indication and to observe the results more accurately than would be possible with small insects. Dimethyl phthalate (DMP) a well known insect repellent was obtained from Jean A. du Crocq Jr. N. V. Huizen, N. H., Holland.

A new method was devised to study the action of repellent vapours on the rate of intact cockroach heart beat. 5 ml of the test

solution was taken into a conical flask (500 ml) and two L shaped glass tubes were fixed to this flask. To one of these tubes, one arm of a T tube was connected with pygon tubing while the other tube is joined to a wide mouthed bottle containing activated charcoal powder. Two thermocol plates each measuring 5 × 5 cm are fixed to a wooden board (20 cm × 10 cm) with adhesive. One male and one female cockroach were placed in the two depressions made near the centre of the thermocol board. The legs and wings of the insects were stretched to expose the thoracic part of the body and were fastened to the thermocol board by a cotton adhesive tape. The antennae of the insect is inserted into the T tube at its base and a measured amount of air (24 l/min) from an airblower is allowed to pass through the charcoal powder to get purified and then through the repellent solution to the insect antennae via T tube.

The heart-beat rate was measured visually under the microscope with the aid of a stop watch. A period one minute was employed for each count and 10 such counts were made to determine the pretreatment rate of pulsations The change in the rate was observed on the resting insect, and compared with that of the same specimen, at rest after treatment. The heart beat of an intact insect was found to continue at a reasonably constant rate provided the temperature did not change and there was no sudden visual or mechanical stimulus. Counts of the heart beat are made at as close interval as possible for the first 10 min, and then at gradually lengthening intervals for the next 90 minutes. The procedure for each concentration of DMP was replicated three times involving six insects in all. Control experiments were conducted with acetone on the cockroach heart with a view to determine the effects produced. Acetone did not produce any perceptible effect on the heart (Fig. 1).

Heart beat frequency of the insects with one antenna excised.

A few experiments were carried out to show the difference in the heart rate between the cockroaches with intact antennae and cockroaches with one antenna excised which are exposed to the vapours of the repellent solution. The right antenna of the cockroach

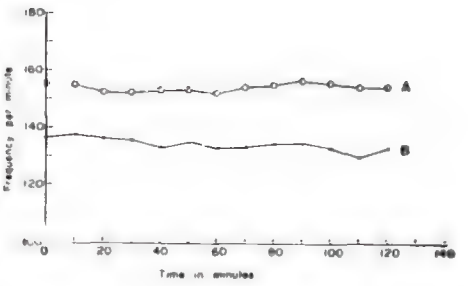

Fig. 1: Heart beat frequency of the cockroaches exposed to acetone.

was cut near its base and immediately sealed with molten parffin wax. The wax solidified and protected the end of the antnnae from bleeding. The left antenna was then inserted into the T tube and the heart beat frequency was measured by the procedure mentioned above. Usually, the rate of heart beat increases or becomes irregular after the excision of the antennae due to post-operational shock. Hence the insect was allowed to overcome this shock for half an hour, after which the heart beat becomes regular.

RESULTS & DISCUSSION

Response of the cockroach heart to the repellent (DMP) vapour varied with the concentration. In nearly all cases a significant increase in pulsation rate developed, the peak occurring from 2–12 min, after passing the chemical vapour. There was an initial acceleration of the heart rate and later it gradually decreased and reached normal, and remained constant. This indicates that the action of repellent is merely temporary. Hearts of male cockroaches were stimulated and raised for a while before reaching normal stage, whereas this was absent in females (Figs. 2a, b, c & d).

An interesting result was obtained at treatments with 10 per cent concentration. A sudden and immediate rise in the frequency was found in the case of males. In female insects, after initial stimulation the heart beat gradually

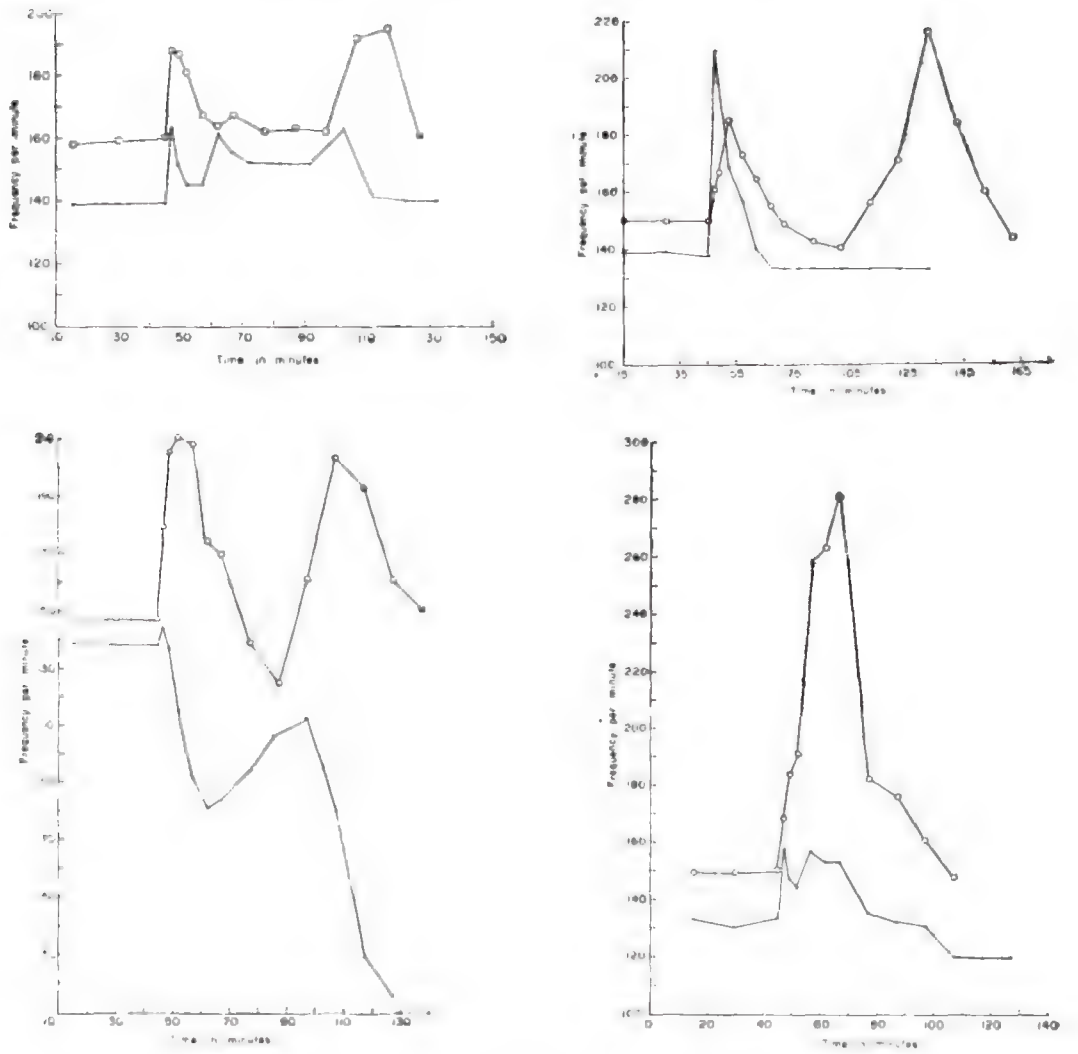

Fig. 2. Effect of dimethyl phthalate at various concentrations on the frequency of intact cockroach heart beat. (Open circles, DMP treatment).

a (upper left) = at 1 per cent concentration.
b (upper right) = ,, 5 ,, ,,
c (lower left) = ,, 10 ,, ,,
d (lower right) = ,, 20 ,, ,,

decreased, became irregular and after a period of 90 minutes the beating was stopped (Fig. 2c). Probably this is an optimum or a threshold of concentration for the maximum response of the females.

The vapours of DMP, without dilution did not produce any significant change in the rate of heart beat. The number of beats varied very little and insignificantly before and after treatment

(Fig. 3). This might be due to the absence of the solvent, since fat solvents allow the entry of the campound into the insect antennae. DMP which is not diluted with the solvent was unable to penetrate through the sensillar cuticle and thus did not show any effect on heart rate. These findings support HAWKE & FARLEY (1971) who reported that the superficial cuticular layer of sensilla could be removed with lipoid solvents and proteases.

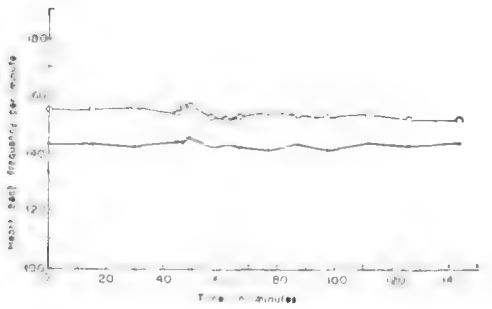

Fig. 3. Effect of dimethyl phthalate without dilution (open circles) on the frequency of intact cockroach heart.

Various views were expressed about the reasons for the changes in the heart beat. Until naw no literature is available as to how the chemical vapours act on the rate of heart beat. According to CHAPMAN (1931) the heart is made to beat faster by a substance from the corpora cardiaca which is presumably normally released into the blood. Release of this substance from the corpora cardiaca is knawn to be induced in *Periplaneta* by feeding on glucose. Chapman explained, as this is ingested sensilla on the labrum are stimulated and impulses pass from them to the corpora cardiaca via the brain and the forntal ganglion. The change in the pulsation of the heart due to the effect of vapours of dimethyl phthalate shows that the insect olfaction will definitely show the physiological effect on heart beat. The odour molecules enter through the cuticular pores of the chemoreceptors, located on the surface of the antennae and trigger the nerve impulse. This stimulation of the nervous system further acts upon the heart and causes the changes in the beating of the heart. Thus, initial acceleration of the heart rate in all the concentrations tested can be explained. The gradual decline and the normal beating after a certain period is due to the saturation of the receptor cells, because too rapid stimulation of an olfactory neuron may not produce a response, but may actually block the neuron and prevent transmission (HAINER & ENSLIE, 1958).

It is interesting to note that both sexes responded in different ways to the repellent vapours of various concentrations. At present it is difficult to offer a decisive explanation for this difference in response. NAIDU (1959) while working on insecticidal effect on isolated cockroach heart had argued that lipid content of an insect has no significant role to play in differential sex susceptibility. It seems probable that cell organization and physiological differences at the cellular level in the female insect are of primary importance. Difference in the biochemical reactivity between an insecticide and enzyme in male and female is unlikely, since the mode of action of the insecticide on the heart in both sexes is similar and differs only in degree.

The response of cockroaches, deprived of one antenna to the vapours of DMP was different than the cockroaches with both the antennae intact. The vapours caused an increase in pulsation

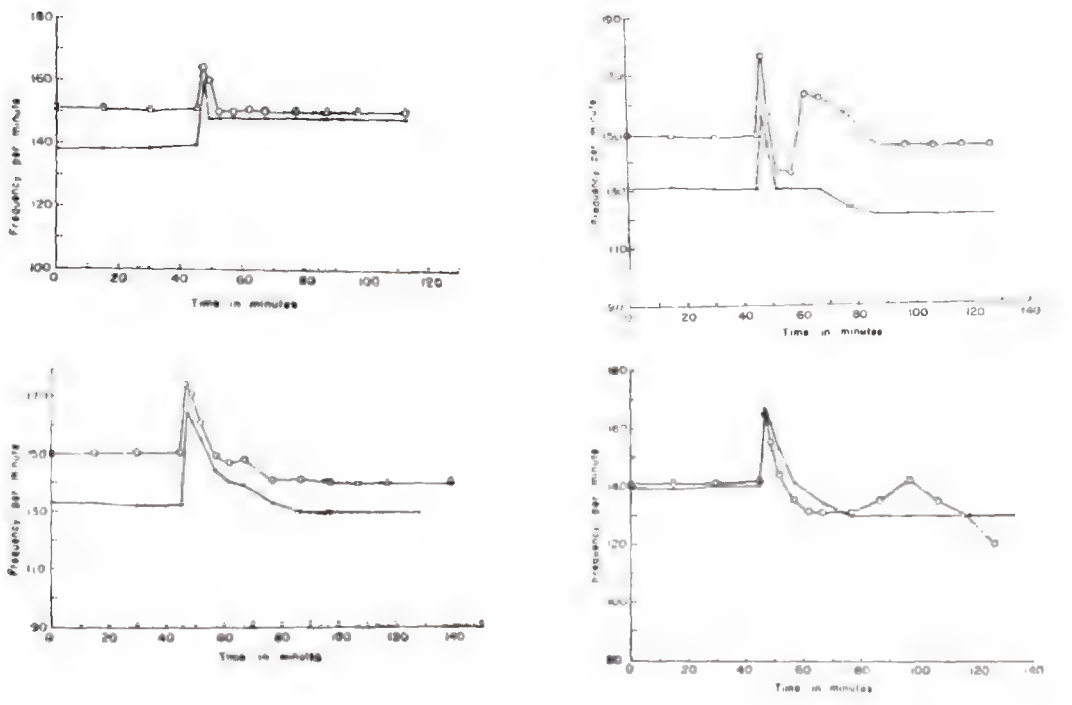

Fig. 4. Effect of dimethyl pthalate at (open circles) various concentrations on the frequency of intact cockroach heart with one antenna amputated.

a (top left) antennae exposed to 1 percent concentration
b (top right) ,, 5 ,,
c (lower left) ,, 10 ,,
d (lower right) ,, 20 ,,

rate, which develops suddenly and remains usually upto 4 min. A gradual decline in the pulsing rate was observed after initial stimulation. Finally, the heart reached its normal stage of beating within 5–20 min. The results for both male and female insects, at all the concentrations tested are almost similar during the period of initial acceleration. At higher concentration the number of beats per minute were more, whereas at lower concentrations it was less (Figs. 4a, b, c & d). These results clearly indicate that antennae of the insects are the primary olfactory organs and their deficiency will certainly affect their chemoreceptive activity. The lesser sensitivity of the heart of antennectomizep cockroach supports the theory that the accelerating effect may therefore be related to the nervous system which receives impulses generated at the chemoreceptors located on the antennae, and affects the heart rate.

The results indicate the usefulness of heart-rate monitoring as a tool in the study of the perception of odors by animals. In the past, this technique was employed for measuring the responses of man (LACEY & LACEY, 1970) as well as animals (FRISCH, 1965) to visual,

acoustic and tactile stimuli. The measurement of intact specimen's heart beat due to different odours has also been used in the course of olfactory studies in birds (WENZEL & SIECK, 1972). While there is uncertainty concerning the underlying mechanisms (KAGAN & LEWIS, 1965) and the most suitable methods of analysis (FIRTH, 1973), there is general agreement that the cardiovascular system is a delicate response mechanism capable of revealing individual variations in reaction to stimuli.

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BRIEF COMMUNICATION

EFFECT OF DIFFERENT INSECTICIDES ON CONTROL OF RICE SWARMING CATERPILLAR *SPODOPTERA MAURITIA* BOISD.

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(Received 19 February 1985)

Field trials conducted on the control of *Spodoptera mauritia* Boisd. showed that sprays of carbaryl 0.1%, methyl parathion 0.03%, quinalphos 0.03%, endosulfan 0.03%, BHC 0.2% and fenthion 0.05% gave effective control.

(Key words: Rice swarming caterpillar, *Spodoptera mauritia*, control with insecticides)

Rice swarming caterpillar *Spodoptera mauritia* is a sporadic pest of rice in Kerala. Collection and destruction of larvae (ANON, 1939), baiting with arsenicals and by flooding (LEVER, 1939), spraying 0.2 per cent DDT at 30 gallons per acre (JOSEPH, 1956), and application of insecticides like BHC, fenthion, methyl parathion, trichlorphan and quinalphos (ANON, 1982) have been recommended for controlling the pest. As the dosages now recommended appeared to be higher than the minimum required an experiment was conducted during the punja season of 1983 to ascertain whether the doses now recommended could be reduced for the control of the pest.

The insecticides were sprayed each at two doses (Table 1) on 30 days old seedlings of Triveni variety severely infested by the pest. Plots of $3m^2$ area were marked out in the field by raising small bunds around each plot. Pre-treatment population from the different plots were assessed by counting the larvae after the clods. The counts were taken from ten spots of 50 cm^2 in each plot. The insecticides were sprayed using a knapsack sprayer ensuring thorough coverage of the plants, using spray fluid at the rate of 300 litres per hectare. Mortality counts were taken 24 hours after spraying adopting the method described earlier. The treatments were replicated thrice.

The results presented in Table 1 show that all the insecticides at both the doses were significantly more effective as compared to the untreated control. Methyl parathion and endosulfan at both the doses, carbaryl at 0.2 per cent and quinalphos at 0.05 per cent mortality of the larvae. All the remaining treatments except fenthion 0.03 per cent and BHC 0.1 per cent were found effective and on par with the above treatments. The lower doses of carbaryl, methyl parathion, quinalphos, endosulfan and the higher doses of BHC and fenthion were found to be effective. In terms of the economics worked for the different insecticides (Table 1) it can be seen that that BHC ranked first (Rs. 18/-) followed by methyl parathion (Rs. 23.40), endosulfan (Rs. 25.70), carbaryl (Rs. 43.20) and quinalphos (Rs. 52,20). Fenthion

TABLE 1. Mortality of larvae of *Spodoptera mauritia* treated with different insecticides.

Insecticides and concentration	Mortality in percentage	Cost of insecticides per hectare
BHC 0.1%	37.5(36.90)	9.00
,, 0.2%	78.6(67.59)	18.00
Carbaryl 0.1%	98.6(86.06)	43.20
,, 0.2%	100.0(90.00)	86.40
Methyl parathion 0.03%	100.0(90.00)	23.40
,, 0.05%	100.0(90.00)	39.00
Quinalphos 0.03%	88.9(78.23)	52.20
,, 0.02%	100.0(90.00)	87 00
Fenthion 0.05%	61.1(56.75)	32.40
,, 0.05%	94.4(81.96)	54.00
Endosulfan 0.03%	100.0(90.00)	25.70
,, 0 05%	100.0(90.00)	42.80
Control	11 1(11.75)	..
CD	23.942	..

Figures in parenthesis are values after angular transformation.

was found to be the most costly (Rs. 54.00) insecticide for application against *Spodoptera mauritia.*

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BRIEF COMMUNICATION

ON THE CONTROL OF BUG *PULVINARIA PSIDII* MASK ON CLOVES

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(Received 19 February 1985)

A field experiment for the control of the mealy bug *Pulvinaria psidii* Mask on cloves using insecticides indicated that dimethoate and methyl parathion sprays gave the best control followed by monocrotophos.

(Key words: colve, mealy bug, insecticides, control)

The mealy bug *Pulvinaria psidii* Mask (Coccidae : Hemiptera) was recorded as a pest of clove by VISALAKSHI *et al.* (1981). The pest colonises the under surface of tender leaves of the plant which results in the yellowing and ultimate withering of leaves. Sooty mould which appears as a secondary pathogen covering the leaves of aggravates the damage. A serious outbreak of the pest was noted in a three year old plantation in Trivandrum District during 1983. An experiment was conducted there with a view to test the relative efficacy of different insecticides in controlling the pest. Randomised block design was adopted for the experiment. Each treatment was replicated thrice taking one plant as a replication.

The insects were counted on marked leaves of the plants and the insecticides (vide Table 1) applied with a knapsack sprayer, to the undersurface of the leaves to the run-off level. The granular insecticides were assessed by observing the reduction of the mealy bug population under the different treatments 3.10 and 60 days after spraying,

The results (Table 1) showed that there was significant reduction in the population of the mealy bug due to insecticidal treatments. On the third day the per cent reduction was maximum on dimethoate treated plants being to the tune of 95.8 and 94 per cent at 0.05 and 0.03 per cent resepectively. They were significantly superior to other treatments. The other insecticides found to give good results were methyl parathion followed by monocrotophos showing a reduction in the pest population being to the extent of 78.1 to 85.3 per cent. In the case of other treatments the per cent reduction in population ranged from 61.8 to 4.2.

On the tenth day after the treatment also dimethoate and methyl parathion were superior to the other insecticides with a reduction in mealy bug population of 98 5 to 100 per cent. Carbofuran granules at 20 g/plant and monocrotophos 0.05 per cent spray also gave comparable pest reduction of 99.2 and 97 per cent respectively. Other treatments did not give significant results.

By the 60th day of insecticide application the only insecticide whose toxic

TABLE 1. Effect of insecticides on control of *P. psidii* on clove.

Insecticides	Dose	Pre-count of mealy bugs	Percent reduction in mealy bug population at different intervals after insecticides application.		
			3 days	10 days	60 days
Carbofuran (Furadan 3G)	20 g/plant	50.33	61.80 (51.82)	99.20 (83.85)	45.73
Carbofuran	10 g/plant	45.00	4.20 (11.87)	47.40 (43.48)	+108.00
Phorate (Thimet 10 G)	20 g/plant	48.00	29.7 (33.01)	85.1 (67.29)	+77.5
Phorate	10 g/plant	46.67	0	11.1 (19.42)	+12.3
Monocrotophos (Nuvacron 40 EC)	0.05%	36.00	83.90 (66.33)	97.00 (80.00)	6.78
Monocrotophos	0.03%	44.67	78.1 (62.07)	85.3 (67.41)	+220.3
Dimethoate (Rogor 30 EC)	0.05%	45.67	95.80 (78.18)	100.00 (90.00)	40.8
Dimethoate	0.03%	44.00	94.00 (75.81)	100.00 (90.00)	+83.3
Methyl parathion (Metacid 50 EC)	0.05%	49.67	85.30 (67.46)	98.50 (82.96)	17.3
Methyl-parathion	0.03%	37.33	82.7 (65.46)	99.7 (86.91)	+57.2
Control		53.00	0	0	+1036.9
C D at 5%			7.45	10.75	..

Values in paranthesis are the angles.
\+ Per cent increase over control. Names of insecticides within brackets are those of proprietary products.

effect persisted to any notable extent was carbofuran granules at 20 g/plant giving a reduction of 45.73 per cent. All the others showed either poor reduction or increase in population.

Acknowledgement: Our thanks are due to Dr. P. SARASWATHY for helping in the statistical layout and analysis of the data and to Sri. S. KUMAR for giving his plot for the experimental purpose.

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STUDIES ON POPULATION DYNAMICS OF CITRUS PSYLLA, *DIAPHORINA CITRI* KUWAYAMA (PSYLLIDAE: HEMIPTERA)

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(Received 24 October 1984)

Studies on population dynamics of citrus psylla at Central Horticultural Experiment Station, Chethalli, Kodagu over three years (1981 to 1983) revealed that the pest was active throughout the year with seven peaks of high population on *Coorg mandarin* with 10 overlapping generations. Computation of per cent incidence of psylla is found to be more appropriate than psylla incidence index or mean number of psylla per flush. Availability of tender flush was the governing factor for the psylla incidence and the climatic factors did not have any impact.

(Key words: citrus psylla, *Diaphorina citri*, population dynamics, *Coorg mandarin*)

INTRODUCTION

The citrus psylla, *Diaphorina citri* Kuw. is found throughout tropical and subtropical Asia and the Far East. It is a serious pest of citrus in northern India (BUTANI, 1979). Nymphs and adults suck the sap from leaves and tender shoots which subsequently dry up. Besides, it also acts as a vector of greening virus causing citrus decline (BINDRA, 1966; BINDRA & CHHABRA, 1967; CAPOOR *et al.*, 1967). EDWIN DHARMARAJU & REDDY (1975) reported that the peak activity of this pest generally synchronises with emergence of new flushes in citrus during January-February and July-August. In Rajasthan the citrus psylla was most active during March-April with 10 overlapping generations (PANDE, 1971). ATWAL *et al.* (1970) made detailed observations on the development of field population of this insect in Punjab during 1965–1967 and reported that the psyllid had 16 generations in a year with 4 peaks of high population during March, June–July, August–September and October–November respectively.

Though earlier workers studied the seasonal behaviour of psylla elsewhere, information on the field population build up under Kodagu conditions is lacking, although *Coorg mandarin* is mainly cultivated in this region. Therefore, an attempt was made to study the extent of population build-up under field conditions.

MATERIALS AND METHODS

Seasonal incidence and population dynamics of citrus psylla on 20 *Coorg mandarin* plants was studied at Central Horticultural Experiment Station, Chethalli, Kodagu, Karnataka. These plants were randomly selected and tagged for observations. Incidence of citrus psylla was recorded at weekly interval on 10 randomly selected tender flushes which were

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located on the outer circumferance on each plant. Total number of eggs, nymphs and adults of psylla were counted and recorded on each flush. Observations were made from January, 1981 to December 1983. The extent of psylla infestation on *Coorg mandarin* was calculated by the following three methods:

a) Per cent incidence $= \frac{\text{sum of infested flushes}}{\text{total no. of flushes observed}} \times 100$

(A flush with only eggs of psylla was accounted).

b) Psylla incidence index: For computing this the flushes were graded based on the presence of total number of nymphs and adults as follows:

grade value	number of psylla per flush (nymph + adults)
0	No psylla
1	1— 5
2	6—10
3	11—15
4	above 15

$$\text{Psylla incidence index} = \frac{\text{frequency in each grade} \times \text{grade value}}{\text{total no. of flushes} \times \text{value of highest grade}} \times 100$$

(While computing this a flush with only psylla egg was not accounted).

c) Mean number of psylla per flush:

The number of nymphs and adults present on all 200 flushes were totalled and averaged per flush.

(While computing this a flush with only psylla egg was not accounted).

Meteorological data for the entire period has been averaged and depicted in the figure.

RESULTS AND DISCUSSION

All the three methods of representing the population fluctuations of the psylla showed the same trend (Fig. 1).

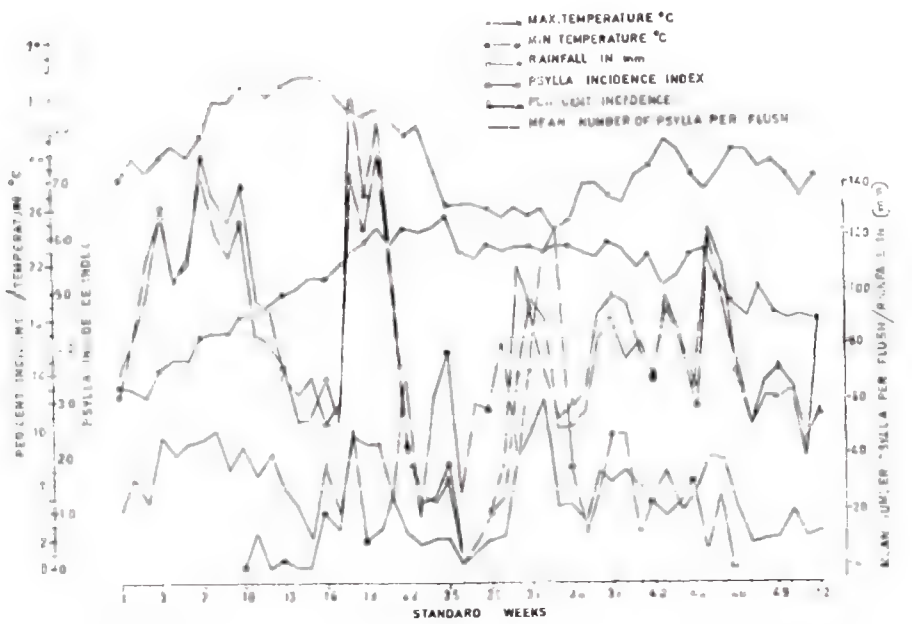

Fig. 1. Population fluctuation of citrus psylla in relation to meteorological data.

The psylla infestation was present on the plants throughout the year. The highest population peak of the psylla was noticed between January 2nd to March 4th week, May 1st week to 4th week, August 1st to 2nd week, September 1st, 2nd and 5th week, October 2nd to 3rd week, November 1st to 2nd week and December 1st week with 10 generatians in a year. Under north Indian conditions as per ATWAL *et al.* (1970) and MANGAT (1967) no activity of psylla was noticed during January which was due to severe cold whereas in the present investigations high population peak of psylla was recorded during January.

From the results it appears that there is no change in the peaks of high population of psylla when the results were presented as either per cent incidence or incidence index. Computation of mean number of psylla per flush was not necessary as the mean number of psylla per flush was less than one.

There were 14 peaks of high population and the peaks on 4th, 7th, 10th, 16th, 25th, 31st, 37th, 41st, 44th and 50th week indicate the different generations. The number of eggs counted indicated 8 generations during 1981, 12 during 1982 and 10 during 1983.

In the present investigation the psylla was more active from January 2nd week to March 4th week, which is in accordance with the reports of PANDE (1971) and EDWIN DHARMARAJU & REDDY (1975). During May 1st to 4th week highest psylla incidence was recorded in the present investigation and none of the above workers could record the highest psylla activity during this month. Further high psylla activity was recorded during August 1st to 2nd week, September 1st to 2nd week, October 2nd to 3rd week, November 1st to 2nd week and December last week, whereas EDWIN DHARMARAJU & REDDY (1975) recorded high psylla activity during July–August and ATWAL *et al.* (1970) during June–July, August–September and October–November. The differences observed between earlier workers and the results of present investigations were due to the changes in flushing periods of citrus in different regions. Most of the earlier reports indicate the months during which the psylla was active whereas the present investigation earmark the week in which the psylla activity was more.

Earlier, seasonal incidence of citrus leaf-miner was studied by BHUMANNAVAR & SINGH (1983). It appears that the high psylla incidence peaks are followed by the high leaf-miner incidence peaks. This may be because of the fact that the psylla infests the tender unopened leaves and leaf miner infests the opened leaves of the same flush.

The climatic conditions however may not directly influence the citrus psylla population but probably affect through influencing the availability of tender leaves (new growth) as in the case of citrus leaf-miner.

Acknowledgements: The authors are grateful to the Director, Indian Institute of Horticultural Research, Bangalore for constant encouragement and facilities provided and to Mr. K. B. KARIAPPA and Miss. M. K. PADMAVATHY for their technical help in collecting the observations.

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BRIEF COMMUNICATION

PATHOGENICITY OF *ASPERGILLUS TAMARII* KITA TO *DASYCHIRA MENDOSA* HUBNER (LEPIDOPTERA : LYMANTRIIDAE) A PEST OF MULBERRY

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(Received 14 November 1984)

Mulberry was found damaged by the Lymantriid *Dasychira mendosa;* mortality among the caterpillars was observed owing to the infection by the fungus *Aspergillus tamarii.*

(Key words: Lymantriid, *Dasychira mendosa,* Fungus, *Aspergillus tamarii,* infection, mortality)

Several species of *Aspergillus* have been reported to be pathogenic to insects. *Aspergillus flavus* Link is known to be pathogenic to *Amsacta albistriga* Wlk, *Opisina arenosella* Meyr., *Aproaerema modicella* Zell. and *Oxya velox.* (F.) (OBLISAMI *et al.*, 1969); *Spilosoma obliqua* Wlk. and *Spodoptera litura* (F.) (BATTU *et al.*, 1971) and *Chilo partellus* Swinhoe (ATWAL *et al.*, 1973). Pathogenicity of *A. tamarii* Kita to *Azygophleps scalaris* (F.) has also been reported (SITHANANTHAM, 1970).

During the period June to August 1983, mulberry was found damaged by *Dasychira mendosa* Hubner (Lepidoptera: Lymantriidae). Mortality among the caterpillars was observed owing to the infection by *Aspergillus tamarii* Kita. The fungus was isolated using Rose Bengal agar medium. The pathogenicity of *A. tamari* to *D. mendosa* and susceptibility of larval instars to the fungus were studied.

The infected larvae became sluggish with reduced feeding efficiency. The passive larvae adhered to the surface of leaves resulting in death after 3 to 4 days of inoculation. Mycelial growth was seen on dead caterpillars 24 h after death. Mycelium was white initially, turned to yellowish-brown after 48 h and brownish after 72 h. The whole surface of cadavers of the first three instars was covered with fungal growth whereas in fourth and fifth instars the fungal growth was confined to posterior part, or anterior head region or in the middle, which later spread all over as the days advanced.

Although all the five larval instars were found to be infected by *A. tamarii,* varied degree of larval mortality was recorded (Table 1). The larval mortality was highest (100 per cent) when first, second and third instars were infected, followed by fourth instar (20 00 per cent) and fifth instar (16.65 per cent). Further, it was observed that 100 per cent mortality was recorded on third day after inoculation in the case of first and second instar larvae while in other instars larval mortality occurred four days after inoculation.

Pre- and post-death symptoms of the infected caterpillars are in agreement with observations of SITHANANTHAM

TABLE 1. Pathogenicity of *Aspergillus tamarii* on different larval instars of *Dasychira mendosa* Hubner.

Instar infected	Per cent larval mortality at different days after inoculation						
	1	2	3	4	5	6	Total mortality
First	—	—	100	—	—	—	100.00
Second	—	—	100	—	—	—	100 00
Third	—	—	—	53.33	36.67	10.00	100.00
Fourth	—	—	—	6.67	10.00	3.33	20.00
Fifth	—	—	—	10.00	6.67	—	16.67

— indicates no mortality.

(1970), except for blackening of larvae after death which was not observed currently. The time taken for 100 per cent mortality was three days in first and second instars, similar to the results of BOYCE & FAWCETT (1947). On the other hand 100 per cent mortality of third instar larvae occurred between 4 to 6 days after inoculation, which is in conformity with the previous reports (BATTU *et al.*, 1971; SITHANANTHAM, 1970) AOKI *et al.* (1972) also reported that *A. flavus* infected fourth and fifth instar silkworm larvae to remain healthy, as observed in case of *D. mendosa* too.

As the age of the caterpillar advances the corresponding time required for mortality increased. Further, the susceptibility for infection decreased as the instars advanced which may be due to maturation immunity. The pathogenicity of *A. tamarii* on *D. mendosa* is reported for the first time.

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EFFECT OF SATURATION DEFICIENCY AND TEMPERATURE ON WATER LOSS AND VIABILITY OF OOTHECAE OF *PERIPLANETA AMERICANA*

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Effect of low and high saturation deficiency and temperature has been studied on water loss and viability of oothecae of *Periplaneta americana*. It has been found that at 4 g/m^3 Sat. Def. there is a very high 90-100% incidence of hatching of oothecae with minimum variation. With the rise in Sat. Def. the viability of oothecae decreases. A positive correlation has been observed between the loss of water and the loss in weight of oothecae of different ages at 8 g/m^3 Sat. Def. and 27 ± 1°C. The viability of oothecae however, markedly decreases at 4 g/m^3 Sat Def. and 20 ± 1°C. This however, is reversed when the temperature is raised to 27 ± 1°C, suggesting that oothecae undergo partial quiescent stage at low temperature.

(Key words: saturation deficiency, temperature, water loss, viability, oothecae, *Periplaneta americana*, cockroach, hatching, weight loss, quiescence)

INTRODUCTION

During rearing of *Periplaneta americana* in the laboratory, the oothecae hatch only to an extent of 70%—75%. GOULD & DEAY (1940), ROTH & WILLIS (1955a, 1955b), KINSELLA & SMYTH (1966) associated it to water loss and keel damage of oothecae by adult insects. The present study was undertaken to find out the most favourable conditions of temperature and humidity that would ensure uniform and reproducible incubation time and thereby bring about an increase in the viability of oothecae in the laboratory maintained colony. Further, since loss of water is a function of evaporation capacity of air (CORNWELL, 1968), the environment of the incubation of oothecae has been assessed in the present study in terms of saturation deficiency of air in relation to particular temperature.

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MATERIALS AND METHODS

A laboratory colony of *Periplaneta americana* was maintained at 27 ± 1°C and 70—7 % RH. The insects were fed on a composite diet containing 18.5% protein, 2.8% fat and 78.7% carbohydrate in terms of dry weight of food. Water was provided *ad-libitum* in pledgets soaked with water. Newly laid oothecae (less than 1 day), weighing between 88—94 mg, were harvested from the colony and divided into four groups with 20 oothecae in each group.

Determination of water content

The water content of oothecae was determined by the method of desiccation to a constant weight at 80°C under 10″ vacuum (ROTH & WILLIS, 1955; BAHADUR, 1963). The difference in the weight of oothecae before and after desiccation was calculated and expressed as percentage of water content.

Determination of saturation deficiency

Initial weight and the weight at different days of the oothecae was recorded. Individual oothecae were kept in petridishes which in trun were placed in glass vessels containing varying concentrations of KOH to maintain predetermined relative humidity (BUXTON & MELLANBY. 1934). The glass vessels were then put at desired temperature in BOD incubator.

Monitered values of temperature and R H inside the glass vessel were computed to determine the saturation deficiency by the following formula:

$$\text{Sat. Def. g/m}^3 = a \frac{a \times \% RH}{100}$$

were a = mass of water vapour in saturated air at temperature 't'. The value of 'a' was read from the table (LANGE, 1966).

The inside temperature of oothecae were recorded by a needle probe YSI Thermometer to assess the effect of incubation temperature on it.

OBSERVATIONS

The water content of 1-day old oothecae maintained at a temperature of 27 ± 1°C and Sat. Def. 8 g/m³ was found to be 64.69 ± 1.46 % (Table 1) but in 30 days old oothecae, the water was reduced significantly in 2 experimental batches. A positive correlation (r) and its significance could be established.

It was considered that loss of water from the oothecae may be one of the reasons for nonviability. To determine this, 1-day old oothecae were divided into four groups (I to IV). Group I to III were incubated at 27±1°C with Sat. Def. 4 g/m³, 8 g m³, and 22 g/m³ respectively. Oothecae of group IV were incubated at 4 g/m³ Sat. Def. but at a temperature of 20 ± 1°C. Fig. 1 shows the loss of water from the oothecae under various saturation deficiency and temperature. It is apparent that as age of oothecae advances, there is increase in water loss. Maximum water loss was recorded in oothecae of group III and minimum in those of group I. In group II, the water loss was inconsistent. Further, the loss in water content of oothecae in group IV was only 13.65 ± 1.25%. The significant difference in the loss of water on day 30 between the oothecae in group I and group IV may be attributed to the embryo at a fairly advanced stage of development. This is a period prior to hatching and more water is required.

TABLE 1. Weight loss and water content of oothecae maintained at 27 ± 1°C temperature and 8 g/m³ saturation deficiency and desiccated at 80°C and 10" vacuum. (Values are mean ± S E of 10 separate determinations).

age of oothecae (Days)	mean weight of oothecae (mg) before desiccation	mean weight of oothecae (mg) after desiccation	mean loss in weight (mg) ± SE	% water content	correlation coefficient (r) and its significance
1	87.9 ± 1.02	31.0 ± 0.58	56.9 ± 0.70	64.69 ± 1.46	0.76 (P< 0.02)
30	69.4 ± 1.06	31.5 ± 0.34	37.9 ± 0.72	54.50 ± 0.56	0.78 (P< 0.01)
30	52.2 ± 1.44	30.0 ± 0 44	22.2 ± 1.05	42.80 ± 1.20	0.937 (P< 0 001)

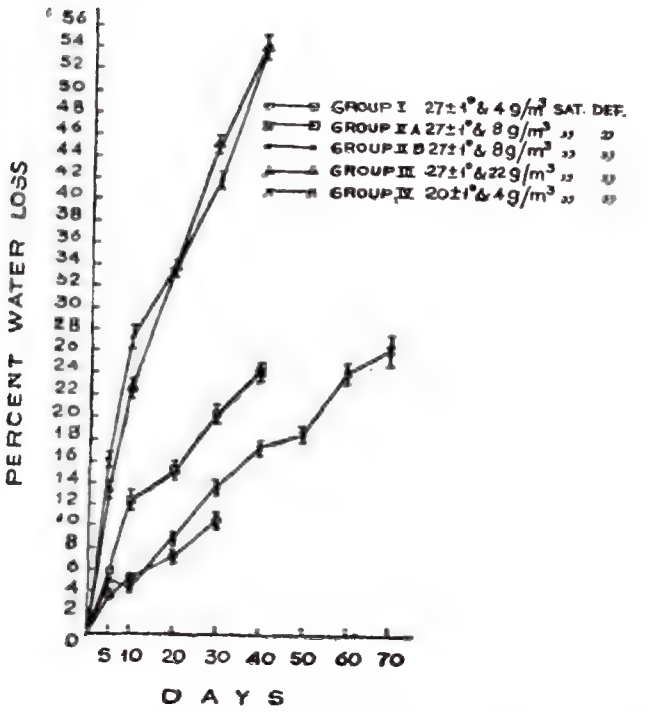

Fig. . Effect of saturation deficiency and temperature on the per cent water loss of oothecae of *Periplaneta americana*.

The incubation period and hatching percentage of oothecae were also markedly influenced by saturation deficiency as shown in Table 2. In group I, all the oothecae hatched out in 35–38 days but in group II, the oothecae hatched out in 41.3 ± 0.25 days. None of the oothecae hatched in group III upto 50 days (thereafter the observations were discontinued). Similarly, none of oothecae hatched in group II till 70 days.

In another experiment, 20 oothecae were incubated at Sat. Def. 4 g/m³ and temperature 20 ± 1°C for 30 days, there was no hatching, subsequently when the temperature was raised from 20 ± 1°C to 27 ± 1°C without altering the Sat. Def., 60% of oothecae hatched on 69th day thus increasing the viability of oothecae.

TABLE 2. Effect of saturation deficiency and temperature on the incubation period and percentage hatching of the oothecae. (values are mean ± S E of 20 separate determinations).

temperature °C	saturation deficiency (g/m³)	incubation period (days)	oothecae hatched (%)
27 ± 1°	4	36.75 ± 0.25	100
27 ± 1°	8	41.30 ± 0.30*	70
27 ± 1°	22	50	None
20 ± 1°	4	70	None

* P< 0.001

* P values represent significance based on Student 't' test.

The effect of incubation temperature on the inside temperature of oothecae incubated at different temperature for 30 days is given in Table 3. It is apparent that incubation temperature greatly influences inside temperature of oothecae. At 20 ± 1°C the inside temperature was slightly above the temperature of environment but at 27 ± 1°C, the inside temperature was higher by about 3°C and this decreases the incubation period and also increases percentage of viability of oothecae.

TABLE 3. Effect of incubation temperature on the inside temperature of 30 day old oothecae. (values are mean ± S E of 10 separate determinations).

incubation temperature (°C) at Sat. def. 4 g/m³	inside temperature of the oothecae (°C)
20 ± 1	21.2 ± 0.13
27 ± 1	30.35 ± 0.08*

* $P < 0.001$

DISCUSSION

In the present study, there was 90—100% hatching of oothecae when the loss of water was minimum in group I. In contrast, oothecae of graup III lost water upto 50% and as a consequence failed to hatch. The loss of water in this group of oothecae was the same as found in oothecae which failed to hatch thereby indicating that non-viability of oothecae is due to greater loss of water. Similar to these findings, ROTH & WILLIS (1955, 1955a) also suggested that viability of oothecae is dependent on the capacity to retain water during incubation in the oothecae of *P. americana*.

Variation in the hatching pattern of oothecae of *P. americana* has also been observed during different months of year by GOULD & DEAY (1938). An analysis of data presented by these investigators show that at the same saturation deficiency (14.4 g/m³). There was a considerable increase in the incubation period at low temperature during October (20–23°C). These findings are in agreement with those observed by us.

Low temperature seem to push the oothecae to state of partial quiescent stage resulting In excessive increase in incubation period. It is possible that at low temperature, the metabolic activity of the oothecae remains at low level as indicated by their inside temperature and it increased when the incubation temperature was raised. The findings presented here indicate that saturation deficiency of 4 g m³ and temperature 27 ± 1°C (Group I) provide the most favourable conditions for the incubation of oothecae of *P. americana* with minimum variation in their hatching pattern.

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BRIEF COMMUNICATION

TWO NEW RECORDS OF HYPERPARASITES ON *OPISINA ARENOSELLA* WALKER, THE CATERPILLAR PEST OF COCONUT

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(Received 1 December 1984)

Meteoridea hutsoni (Nixon) and *Elasmus nephantidis* Rohwer were recorded as hyperparasites of *Opisina arenosella* Walker, the black-headed carerpillar pest of coconut for the first time. They parasttised *Apanteles taragamae* Vier. and *Bracon brevicornis* Wesm. respectiveiy which were primary parasites of the pest.

(Key words: Meteoridea hutsoni, Elasmus nephantidis, hyperparasites, *Opisina arenosella)*

Meteoridea hutsoni(Nixon) (Hymenoptera : Braconidae) was first described by Nixon (1941) as a solitary endoparasite of *Sylepta derogata* (F.) Lepidoptera : pyralidae). The species was later recorded as a primary parasite of *Opisina arenosella* Walker (Lepidoptera : Cryptophasidae) by Sudheendra Kumar *et al.* (1979). The present authors observed for the first time its hyperparasitic nature on *O. arenosella.*

As a primary parasite of *O arenosella*, *Meteoridea hutsoni* showed 10.4 per cent parasitism during the year 1981–1982 in Thikkodi, Calicut Dist., Kerala (Ghosh & Abdurahiman, 1984). In the same area during the year 1983–1984, it showed 17.14 per cent parasitism on *Apanteles taragamae* Vier. (Hymenoptera : Braconidae) one of the primary parasites of *O. arenosella*, while the percentage of its primary parasitism on the pest was 9. In the laboratory the hyperparasite parasitised the final stage larvae of *A. taragamae* soon after emergence of the latter from the host body, laying a single egg in each parasite larva. The parasitised larva soon spun a cocoon and changed into pupa. Further development of the hyperparasite took place inside the host pupa. In contrast to those reared from *O. arenosella*, the adults of *M. hutsoni* emerging as hyperparasites were smaller in size and short lived surviving for 3 days when fed.

Elasmus nephantidis Rohwer (Hymenoptera : Elasmidae) was also recorded hyperparasitic on *O. arenosella.* Adults of the species were obtained from the cocoons of *Bracon brevicornis* Wesm. (Hymenoptera : Braconidae) collected from the fields at Thikkodi, where its percentage of hyperparasitism was very low. In the laboratory it readily oviposited in the prepupal stage of *B. brevicornis.* For successful oviposition the parasite took an average of 1.5 minutes, generally laying one egg in each host. Occasionally the hyperparasite laid more than one egg in the same host, in which case both of them faild to complete their larval development. The eggs hatched after 20 hours of incubation. The larval and pupal stages were completed in 3

and 5-6 days respectively. The total life-cycle of the hyperparasite was completed in 9.5 days which was nearly similar to its life-cycle as a primary parasite as observed by Salomi (1984).

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